PAINT and VARNISH Production

THE TECHNICAL MAGAZINE FOR MANUFACTURERS OF PAINT, VARNISH, LACQUER AND OTHER SYNTHETIC FINISHES

NVENTION

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ISSUE

OCTOBER
1956

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● From widely located plants and warehouses Reichhold offers fast delivery of quality-controlled synthetic resins and chemical pigment colors for use in the manufacture of surface coatings. Following is a list of the major categories of RCI resins. Detailed information is available in Technical Bulletins. When you write for these, please indicate the type of surface coating you are formulating.

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PAINT and VARNISH Production

(REG. U.S. PATENT OFFICE)

Formerly PAINT and VARNISH PRODUCTION MANAGER

(Established in 1910 as The Paint and Varnish Record)

VOL. 46 — OCTOBER, 1956 — NO. 11

NEXT ISSUE

The November issue will carry an interesting article on the Thin Film Evaporometer developed by the Shell Chemical Co., and how it is used as a guide in formulation automotive lacquer thinners.

A report on the Federation convention in Cincinnati and the 21st Paint Industries' Show will also be included in this number.

FEATURES

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Editorial Comment

October, 1956

See You in Cincinnati

A WELL-rounded technical program has been planned for the 34th annual meeting of the Federation of Paint and Varnish Production Clubs during October 22-24th in Cincinnati. In view of conveying expert technical advice for those attending this meeting, the Federation has gone all-out in arranging several informative panel discussions and talks.

An annual feature of the Federation meeting since 1949 has been the Joseph J. Mattiello Lecture. This year's Lecture will be delivered by Maurice Van Loo, director of paint research for the Sherwin-Williams Co. Mr. Van Loo has been associated with the paint industry for almost 30 years. He is the author and co-author of numerous publications in the field of physical and colloid chemistry. His work in paint technology is chiefly concerned with the study of critical pigment volume concentration of paints, and the rheology of paint systems. One of his special projects has been the study of a particular form of metal corrosion called "filiform corrosion." His lecture will be "Physical Chemistry of Paint Coatings—A Constant Search."

As in the past, several constituent club papers dealing with various technical subjects will be presented. Both FATIPEC and JOCCA will sponsor papers.

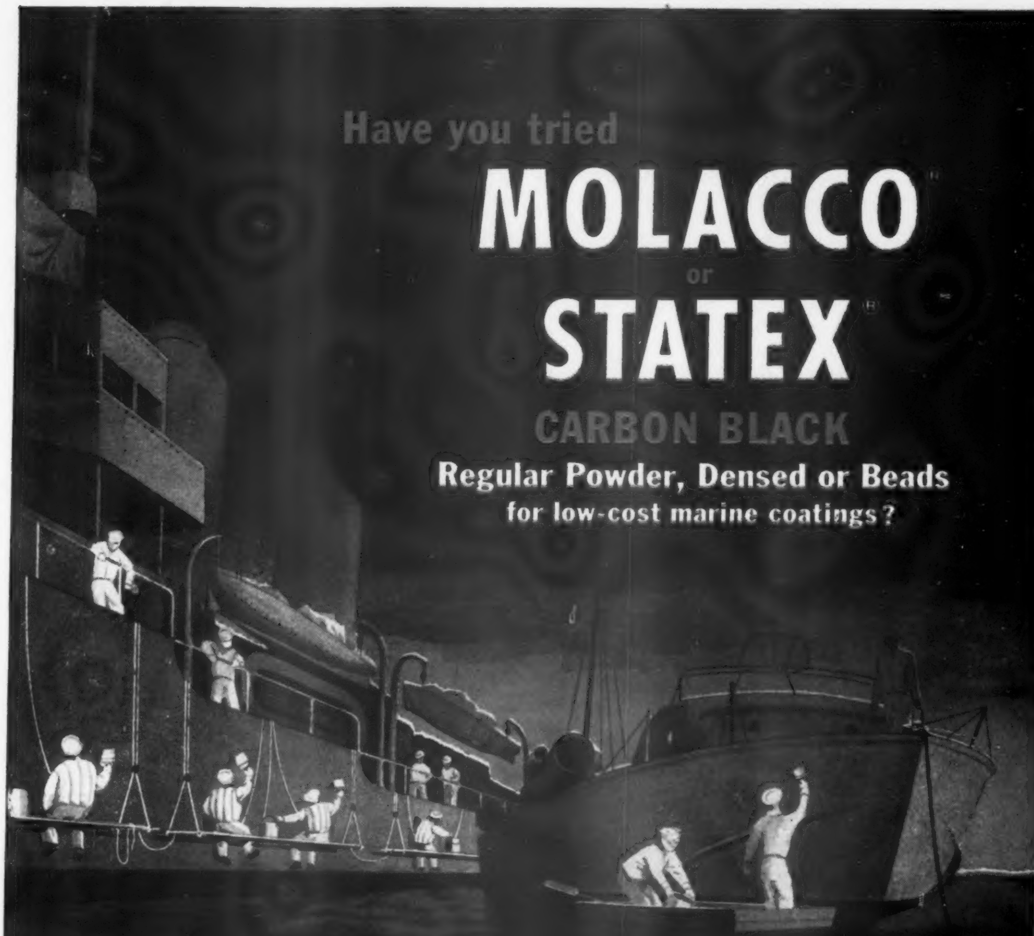
This year's annual meeting will be highlighted by four important panel discussions. These include Chemical Resistant Coatings, Production, Color Measurements, and Blister Proof Paints. Experts in each particular field will be on hand to present their views and also answer questions.

The latest developments in materials and equipment for the protective and decorative coatings industry will be presented by 90 exhibitors at the 21st Paint Industries' Show. It is expected that this year's show will be the best ever presented, not only in number of exhibitors but also in educational value as well.

For the sixth successive year a Lacquer Information Center will be presented through the cooperative effort of suppliers of basic raw materials for lacquer. The theme is "Unlimited Markets for Lacquer" and will depict the latest developments in lacquer technology, formulation, and application. These developments include the latest work on nitrocellulose-acrylic resin blends in automotive lacquers, service-testing of floor finishes, one-coat air-drying hammer lacquers, and specialty formulations for film, foil, and sheeting.

Another feature of this year's show will be a Color Metric Exhibit composing seven firms who specialize in the manufacture of color measuring devices.

The Paint Industries' Show has two distinct functions: (1) to introduce new materials and equipment and (2) to serve as a focal point where technical and production men can look for answers to their problems. Since technical representatives will be available at all times, this Show presents an excellent opportunity for one to review, at one time, the most recent developments in raw materials and equipment. It is through the interchange of ideas between the paint manufacturers and suppliers that will materially help to foster the technological progress of the protective coatings industry.



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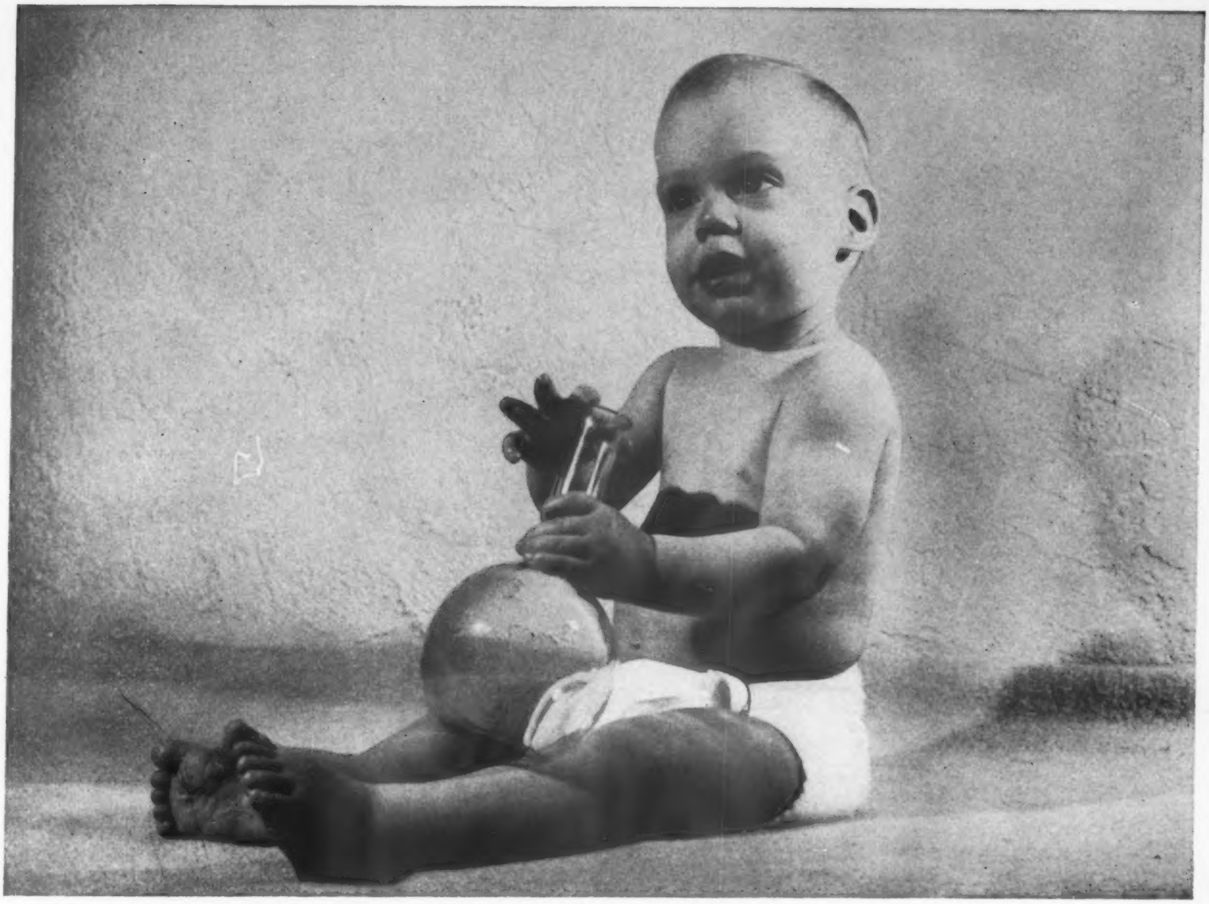

How to Keep Your Production Chemist Young

That top-flight production chemist of yours may often wish he *were* enjoying his cradle days again—particularly when he's being haunted by production troubles due to variations in chemical materials quality.

Fortunately, there's one *sure* way to help him avoid these hair-graying experiences: *Buy proven, first quality materials*. When you specify uniform, high purity *Pittsburgh* Phthalic Anhydride, for example, you enjoy these positive benefits:

1. Production problems due to inconsistent phthalic quality are eliminated.
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4. Customer complaints are reduced, costly adjustments and service calls are cut to the bone.
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And to this list you can add Pittsburgh's reputation for fast reliable deliveries and the complete facilities of its technical service department. *Ask your Pittsburgh man for proof of these benefits. He has the complete story.*

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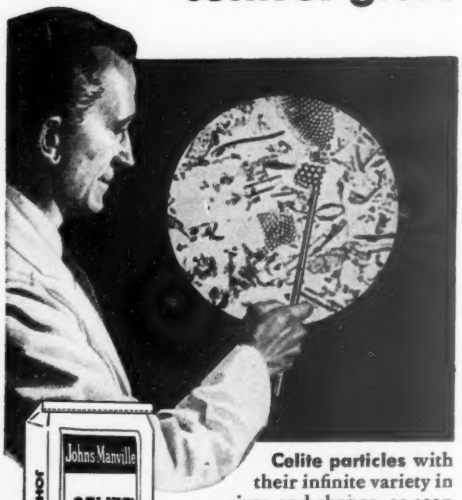

Celite particles with their infinite variety in sizes and shapes, as seen in photomicrograph, diffuse light to control gloss.

FOR YEARS, Celite* has been known as an excellent flatting agent that offers complete control of gloss to any desired degree. But did you also know that, unlike other flatting agents, Celite shows no adverse effect on the washability of the paint film . . . in fact, these microscopic particles of silica actually reinforce it with extra strength and durability.

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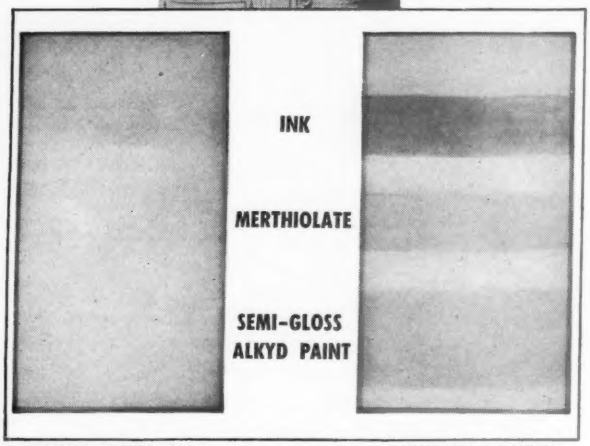
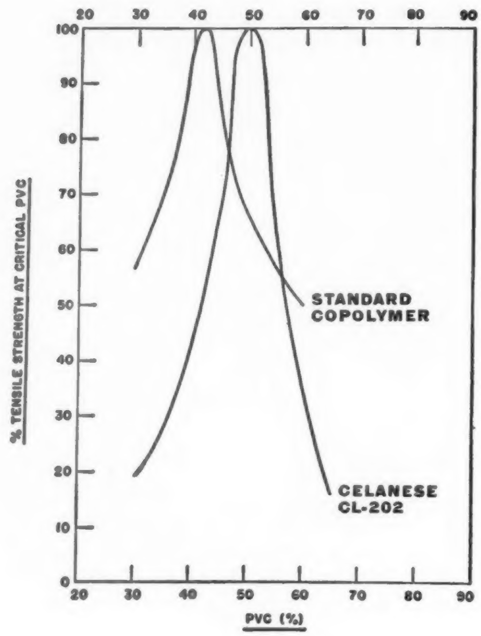


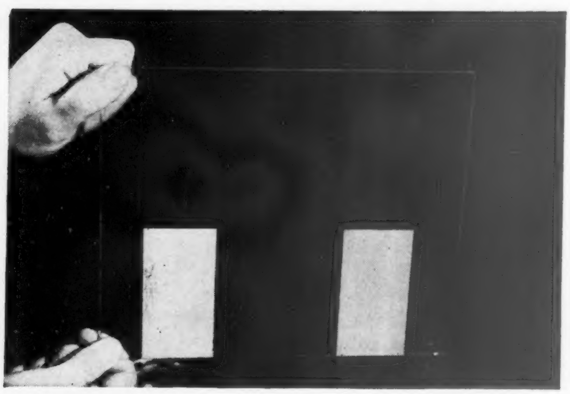
PRIMER SEALER WITH CELANESE EMULSION

PRIMER SEALER WITH STANDARD EMULSION



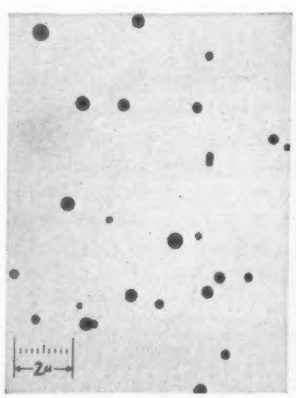
LOW TEMPERATURE COALESCENCE. Pictured above are two primer sealers identical in formulation except for the emulsions used (both homopolymers). These primers were cast (4 mil wet film) at *34° F. on glass* and allowed to *cure overnight at this temperature.* The paints were then stained and photographed from the reverse side of the glass. The primer on the left made with Celanese PVAc exhibited superior film coalescence as evidenced by the sharp reduction in stain penetration.

HIGH PIGMENT BINDING. Celanese emulsions are designed as paint vehicles. Because of this they exhibit extremely high pigment binding capacity. The above graph was prepared by plotting the tensile strength of paint films at progressively higher PVC's. A standard formulation was used and only the emulsions differed. In this comparison (both copolymers) the Celanese emulsion exhibited a critical PVC of 8% above the other copolymer.



STANDARD HOMOPOLYMER CELANESE CL-102 STANDARD COPOLYMER

SUPERIOR WATER RESISTANCE. Pictured above are three drawdowns of unpigmented PVAc films. (Both homopolymers plasticized with DBP.) The films were dried 72 hrs., then immersed in water for 5 min. The CL-102 film in the center maintains its crystal clear appearance and is substantially unaffected by the water.



CELANESE EMULSION

STANDARD EMULSION

FINE PARTICLE SIZE. The "inside story" of Celanese improved PVAc emulsions is clearly demonstrated in the above photomicrographs. Fine particle size indicates higher pigment binding, better non-settling, tighter, more closely knit films and better penetration of chalky or porous surfaces when applied at low viscosities.

OR HOMOPOLYMERS...

both Celanese PVAc Emulsions can give you highest quality latex paints

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And we can back up these claims because Celanese PVAc emulsions are specifically designed as paint vehicles and represent the latest advances in PVAc emulsion technology . . . advances like these:

Can be formulated at PVC's approaching those of alkyd flats.
Extremely fine particle size.
Superior low-temperature film coalescence—even below 40°F.
Tough, flexible, weather-resistant films.
Superior freeze-thaw stability.
High solids content: 55% ± 1.
Superior pigment wetting ability—extra margin of safety against flocculation difficulties.
Crystal-clear, water-resistant films.
Excellent mechanical stability; can even be milled.

A Celanese technical representative will be happy to discuss these characteristics with you and assist you with any technical problems you have. In addition, Celanese has prepared a manual of standard laboratory tests by which you can determine the properties of any resin emulsion vehicle. You can obtain a copy of this manual along with technical bulletins covering Celanese PVAc paint emulsions by filling out and mailing the coupon below.

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☐ Please send me samples of Celanese PVAc Homopolymer and Copolymer Emulsions for paints.

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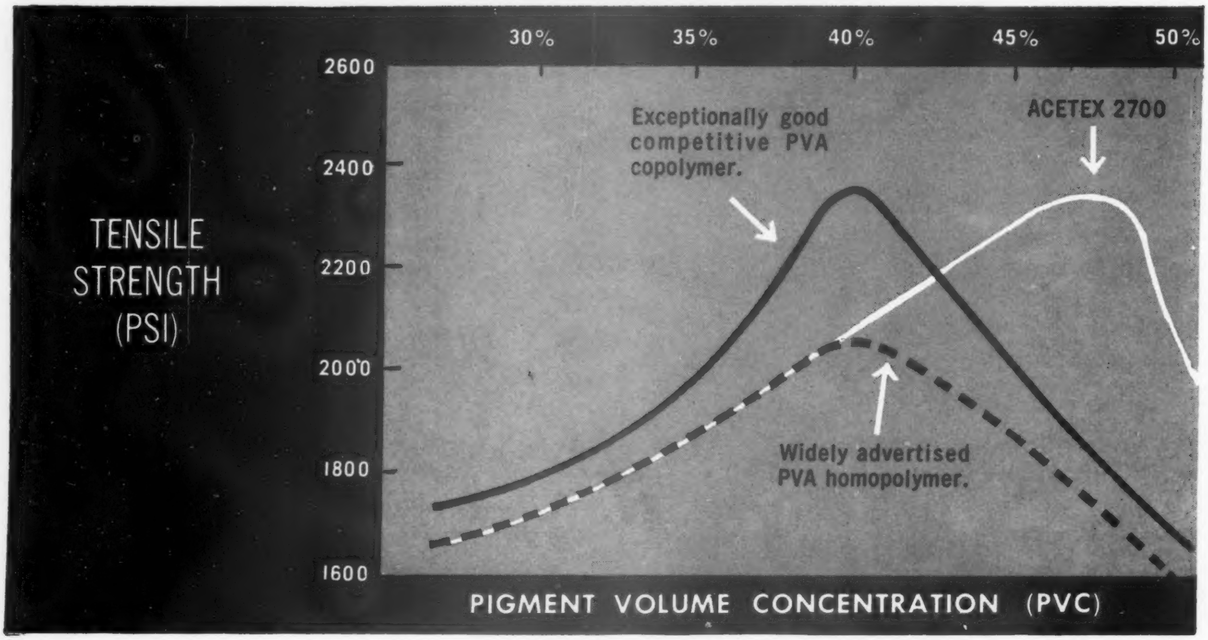
A new Vinyl Acetate Copolymer Emulsion with extremely small particle size.



cuts cost, improves quality, of PVA paints

You don't have to be a chemist to get the cost-saving significance of the above graph! The white line shows the *film strength*—in relation to pigment volume concentration (PVC)—of a paint formulated with ACETEX® 2700 as the pigment binder. Note that the film reaches its greatest strength at about 48% PVC. Naturally, the ability of a latex to bind *more* pigment means *savings* in your raw material costs.

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STATISTICAL METHODS *in the* COATINGS INDUSTRY

Compiled and Edited

By

JOSEPH W. PRANE*

In Collaboration with Editorial Staff

of Paint and Varnish Production

*Mr. Prane is connected with the National Lead Co., Oil and Resin Laboratory, Philadelphia, Pa.

FOREWORD

THE purpose of presenting this particular feature on "Statistical Methods in the Coatings Industry" is to acquaint you with the many benefits that can be reaped from the application of statistical procedures in three important areas of paint technology—research and development, testing and evaluation, and production.

We are all well aware that the study of surface coatings is attended by many difficulties stemming from the inability to obtain reproducible test results. Uncontrollable factors such as atmospheric conditions, thickness of paint films, human element, etc.—all contribute to varying results of a particular test method. In addition, many properties of paint films must be approximately measured, since, in many cases, there are no satisfactory test methods available.

It is in this particular phase of coating technology that statistical methods have much to offer. For in statistical techniques we have the tools and power to design our test methods, analyze our test result, correlate our findings, and predict precision and specification compliance. But most important is the fact that statistical methods can provide reliable results for making decisions.

Many will ask what is required to utilize statistical techniques in the ordinary paint plant. First of all laboratory individuals must be versed in statistical methods to plan experiments and analyze data. This may be accomplished by training key laboratory personnel in the various phases of statistical procedures by holding scheduled seminars within the company or having individuals attend a short course in statistics. Such training should adequately prepare the individual to apply statistical methods in most of the problems he encounters. For advanced techniques, the services of a professional statistician are needed.

In the way of equipment, a calculating machine is a necessity and the type chosen will depend on the amount of computation involved.

In conclusion, we would like to emphasize that the cost of utilizing statistical procedures in your laboratories and plants is exceedingly small when compared with the many savings and advantages that can be derived from such a technique.

—EDITOR

BACKGROUND of STATISTICAL PROCEDURES

MANY companies and organizations in the chemical industry are enjoying economies of operation and increased precision of results thought unattainable just 10-15 years ago. Did some miracle bring this about? Hardly. Rather it was a slow, but steady evolution of the use of statistical methods for the presentation and analysis of data and interpretation of results.

Formerly, these methods were the province of mathematicians, biologists and various groups in the social sciences, such as agronomists, psychologists and actuarians. Chemists and other physical scientists used numbers and their interrelationships during their experimental work. However, many of them were loathe to employ statistical analysis, even if they may have been familiar with the concepts, because the particular factor or property they were studying could usually be measured so closely, and would vary over such a small range, that the true value could be established within narrow limits. Indeed, measurements of an absolute nature, such as atomic numbers, or the speed of light, were entered into our record books without the use of statistics as we know it.

It was during World War II that the omnipotent statistical methods, borrowed from the social scientists, and introduced into the war effort, made their mark and received their impetus. In the fields of quality control, sampling, inspection, fire control, and artillery and shell design, use of these methods resulted in a considerable reduction of critical manpower requirements with a usual gain in precision and accuracy of results.

> *"Statistical procedures and experimental design are only two different aspects of the same whole and that whole is the logical requirements of the complete process of adding to natural knowledge by experimentation."*
>
> **Ronald A. Fisher**

During the years that statisticians were developing statistical techniques, marked changes were taking place in pure and applied research (28). The problems became more complex, tolerances became tighter. Successful competition called for more than buying cheap and selling dear. Successful competition called for making better products at lower costs. Large industrial research laboratories came into existence and great research institutions pooled the skills of many investigators to solve these problems. Research and development budgets were increased and became an important item in the cost of production. At this point there was good reason to examine both the planning of research projects and the laboratory execution of the work to see if any techniques were being overlooked that would increase the return obtained from the research and development dollar.

This examination led a number of industries and laboratories to look more closely at the hitherto ignored, and sometimes despised techniques of statistics. It was found that statistics and particularly the statistical design of experiments had potentially impressive leverage effects on the amount of information obtained from experimental work. Many engineers and scientists began to study statistics. It speaks well for the subject that even the elements, picked up in a few hours, yield impressive dividends.

Efforts toward improving research thinking and research methods must be continued vigorously (3). Two major blocks to progress are still very much in evidence; hence, for the adherents of the statistical approach, this task still remains rather formidable. The first block regards the applicability of many of the statistical methods. There is sometimes an extremely wide gap between a statistical model and the composition of an experiment—assumptions which cannot be met, variables which are difficult to control, and procedures which may be difficult to execute. An effective compromise can be agreed upon, perhaps by both modifying the statistical model into a less stringent, more workable form, and also, at the same time, making minor changes in the manner of performing the experiment.

The second impediment, and the more difficult to resolve, is the sheer lack of recognition among research personnel that the statistical method is a truly effective and powerful tool in scientific research. The statisticians themselves are not free of responsibility for the unfortunate situation, for often their uncompromising in-

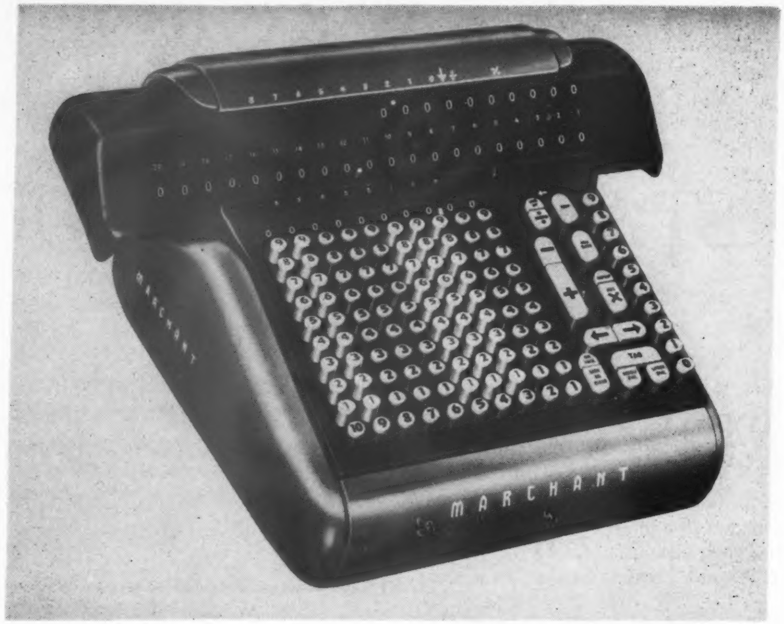
sistence on unduly stringent statistical models or their over-emphasis of mathematics has taken the place of correct sympathetic interest in the field of application, eg., chemistry, engineering, biology, etc. Hence a research worker who might otherwise be cooperative has been alienated. Compromise here would be important, since the research and development worker does not have to be a statistical purist to make use of these methods.

Most researchers have intuitively organized their work on a factorial basis even though they do not actually go ahead to the final analysis of variance. Here, statistics might be termed "scientific intuition", because it goes one step further in helping a scientist draw more reasonable conclusions from the data obtained in an experiment set up under the scientific method.

Applications of statistical methods are universal; particular application to the coatings industry involve design of experiments in research and development, pigmentation studies, vehicle components, exposure testing, and pilot plant work. Examples of use in quality control and production include; purchasing and product specifications, sampling plans, control of pigments, oils, resins, thinners, production control, correlation tests. These will be discussed in detail in later sections with particular reference to savings of material and manpower in testing and batch holdup.

These methods are not restricted to large companies, to be considered as a luxury to be enjoyed only by those with expensive technical budgets. The techniques are relatively uncomplicated (if one foregoes the derivations). They can be used by individuals and organizations of any size. All that is needed is the know-how, a calculator, the data and situation to analyze and a desire to get the best results possible in the most economical fashion.

Quoting a recent editorial, (42) "The use of statistical techniques for the evaluation of data, for making decisions, and for designing experiments is rapidly becoming another powerful management tool. When properly used, they may save money and valuable time. . ."



Courtesy of Marchant Calculators, Inc.

Calculator is said to be completely automatic for multiplication, division, addition, subtraction, and carriage control. Multipliers may be entered forward, as you read them, or backward. Also performs positive and negative multiplication.

Courtesy of Monroe Calculating Machine Co.

This calculator is said to be designed and engineered to handle standard deviations (grouped and ungrouped) linear and multiple correlation, analysis of variance and for computing control limits both modified, average and std. deviation.

FUNDAMENTALS and TOOLS

> *"When you cannot measure what you are speaking about, when you cannot express it in numbers, your knowledge is of meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the stage of a science, whatever the matter may be."*
>
> **Lord Kelvin**

OUR chemists in our development and control laboratories are constantly making measurements of such properties as fineness of grind, weight per gallon, acid value, non volatile content, tinting strengths, etc. Frequently, they make measurements in duplicate or triplicate—thinking that repetition of the measurement will lead to reproducibility of results. Intuitively, most chemists realize that measurements without "Checks"—without a rough determination of precision or experimental error—are almost meaningless.

They realize that many factors, both known and unknown, will influence their tests. For example, some of the known factors are temperature, atmospheric pressure, humidity, standardization of weights, measures and titrating solutions. These and many others are known to exist and have some effect upon the precision (reproducibility and accuracy (relation to a standard) of these results.

But over and above these known causes for error are the unnumbered unknown, chance, uncontrollable randomly occurring causes for deviations—made up in part by interactions between many of the known causes.

If the chemist or operator gets different results when he checks hiding power of a paint—what or who is to blame? Is it the test method, the operator, the instrument used—or perhaps a combination of all of these variables and many more, that contribute to the makeup of a particular test result.

Also—using the same paint and test method, will the operator get the same set of results tomorrow or next month? Will he get the same results as a different chemist working under the same conditions?

We all know that problems of this type come up continually in quality control, specifications and referee work—also in cooperative work and sponsored work such as Technical Committees, ASTM or AOCS. What we may not realize is that in statistical techniques we have the tools and power to design our tests and methods, analyze our test results, correlate our findings and predict precision and specification compliance to the extent that management wishes to pay for.

The remainder of this paper will attempt to show, in a simplified manner, what some of these tools are, and how more specific knowledge can be obtained and used. No attempt will be made to cover the field thoroughly; this is obviously impossible in the space allowed. However, the literature of statistics and associated techniques is extremely well developed, both in its theoretical, mathematical and practical manifestations. Many references will be cited, where the interested reader can pursue the subject further.

Concepts

Statistical methods involve the collection, presentation, analysis and interpretation of numerical data. The structure of the whole statistical analysis depends on the trustworthiness of the first element—the raw data.

An illustration cited by Stamp is to the point (21): Harold Cox, when a young man in India, quoted some Indian statistics to a judge. The judge replied, "Cox, when you are a bit older, you will not quote Indian statistics with that assurance. The government are very keen on amassing statistics—they collect them, add them, raise them to the nth power, take the cube root and prepare wonderful diagrams. But what you must never forget is that every one of those figures comes in the first instance from the "chowty dar" (village watchman), who just puts down what he damn pleases." It should be added that this story refers to the India of a day long past. Today India has many able statisticians and an active statistical society. Presumably the "chowty dar" no longer functions as the source of local statistical information.

Fortunately modern statistical methods are quite discriminating. False data usually becomes apparent early in the analysis, and

warning signs are set up to guide the experimenter into more fruitful channels.

Frequency Distributions

Let us start by looking at a historical set of data—typical of what may have been found or compiled in our industry. In Table 1 are shown the distribution of data on gloss readings for 113 samples of a white paint. (72 hour air dry—Gardner 60° glossmeter)

It is apparent that very little information is forthcoming unless the figures are rearranged, since, when the data are in this form, it is a tedious job to find even the lowest and highest value. It is more difficult to ascertain around what value the figures tend to concentrate or if indeed they do show such a concentration. These and other steps in analysis are facilitated by rearranging and summarizing the data.

In Table 2, the data has been arranged in an *"Array"*, in descending order of magnitude. This arrangement shows the range of the data to be from *3* to *46* with an apparent concentration in the neighborhood of *16-20*.

Table 3 shows the data of Table 2, summarized in a *"Frequency Distribution"*. It is obvious that the Frequency Distribution does not show the details given in the array but much is gained by the summary. The range and concentration of values are still shown as before. The frequency of occurrence of the data within *10* classes or groups chosen is the salient point. The class interval, i, comprises 5 units of gloss.

Having thus classified the data, rapid computations of many other properties of this distribution can be made (shown later), which will assist in describing and analyzing the data.

Figure 1 shows a plot of the data in Table 3 as a frequency distribution curve. Examination of the graph shows that the midpoints of the classes or groups chosen are plotted on the abscissa and the frequency of occurrence, f, is plotted on the ordinate. The number of classes are chosen so that the distribution will not show noticeable irregularities, when plotted (too many classes) or that so many frequences will be crowded

(Gloss) X	X^2	(Gloss) X	X^2	(Gloss) X	X^2
16	256	37	1369	27	729
13	169	24	576	24	576
15	225	28	784	39	1521
5	25	32	1024	12	144
26	676	46	2116	25	625
23	529	21	441	28	784
25	625	23	529	25	625
14	196	20	400	15	225
35	1225	17	289	8	64
43	1849	26	676	3	9
20	400	28	784	18	324
30	900	20	400	19	361
37	1369	43	1849	21	441
32	1024	20	400	4	16
23	529	20	400	20	400
25	625	27	729	7	49
33	1089	14	196	18	324
26	676	21	441	10	100
35	1225	20	400	13	169
23	529	34	1156	15	225
37	1369	15	225	9	81
33	1089	39	1521	11	121
33	1089	35	1225	9	81
21	441	28	784	8	64
42	1764	31	961	8	64
23	529	22	484	33	1089
46	2116	11	121	9	81
32	1024	10	100	19	361
23	529	9	81	29	841
19	361	24	576	18	324
28	784	28	784	20	400
16	256	40	1600	8	64
28	784	31	961	15	225
16	256	20	400	36	1296
18	324	23	529	15	225
16	256	40	1600	19	361
39	1521	43	1849	38	1444
46	2116	37	1369		

$\Sigma X = 2677$ $\Sigma X^2 = 75{,}721$ $N = 113$

$\overline{X} = 23.70$

Table 1. Raw data showing gloss readings of 113 white paints.

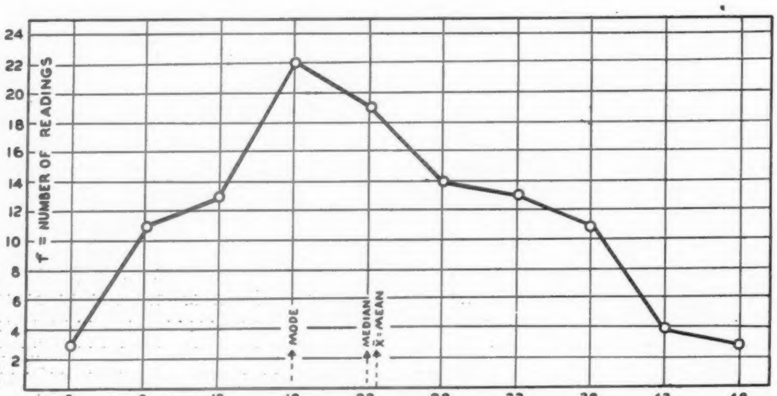


Figure 1. Frequency distribution curve of gloss readings of 113 white paints.

into a class as to cause much information to be lost (too few classes).

In general, it might be said that from 6 to 16 classes should generally be used. An absolute minimum to be used may be learned from the following equation:
where i = the class interval and N = the number of items in the distribution.

$$i = \frac{\text{RANGE}}{1 + 3.322 \log N} \quad (1)$$

The class intervals and limits should be so selected that the mid-points are truly representative of each class.

An interesting and useful representation of such data can also be made in a "Cumulative Frequency Distribution". In Table 4, the data of Table 3 is rearranged to show how many and what proportion of the paints had gloss readings more than the stated figures. The absolute data is plotted in Figure 2 and the % values in Figure 3 (on Probability Paper). These curves are called "*Ogives*" and are helpful in visually classifying data as to quality or magnitude. (If the Ogive of the data on the arithmetic probability paper is a straight line, the so called "normal curve" may be used to describe the distribution.)

Central Tendency

Now let us examine some of the properties of such data distributions: First we will consider the various measures of "*central tendency*"—that is the characterization of the values that tend to concentrate in the center of the distribution.

Mean

Most familiar of these is the "*Arithmetic Mean*" or more commonly, the "*Mean*" or the "*Average*" or the "*Norm*". This of course is obtained by summing the values and dividing by the number of values.

$$\bar{X} = \frac{X_1 + X_2 + X_3 + \cdots + X_n}{N} = \frac{\Sigma X}{N} \quad (2)$$

For a frequency distribution, the arithmetic mean may be calculated as follows:

$$\bar{X} = \frac{f_1 X_1 + f_2 X_2 + f_3 X_3 + \cdots + f_n X_n}{f_1 + f_2 + f_3 + \cdots + f_n} = \frac{\Sigma f X}{N} \quad (3)$$

46	30	20	10
46	29	20	10
46	28	20	9
	28	20	9
43	28	20	9
43	28	20	9
43	28	20	8
42	28	20	8
	28	20	8
40	27	19	8
40	27	19	7
39	26	19	
39	26	19	5
39	26	18	4
38		18	3
37	25	18	
37	25	18	
37	25	17	
37	25	16	
36	24	16	
	24	16	
35	24	16←Q_1	
35	23		
35	23	15	
34	23	15	
33	23	15	
33	23←Median	15	
33	23 (Q_2)	15	
33	33	15	
32	22	14	
32←Q_3	21	14	
32	21	13	
31	21	13	
31	21	12	
		11	
		11	

Table 2. Array of data of gloss readings of 113 white paints.

where $X_1, X_2, X_3 \ldots$ represent the midpoints and f_1, f_2, f_3 the frequencies.

For the distribution shown in Table 1, $\bar{X} = 23.70$, by equation (2). Equation (3) yields a value of $\bar{X} = 23.50$, which is very close to *23.70*.

Several short cuts to the computation of $\bar{X}$ for grouped data exist. These depend on the assumption of a value $\bar{X}_d$ as the Mean and computing the necessary correction to obtain $\bar{X}$. Here the symbol, d, signifies $X - \bar{X}_d$ and $\bar{X}_d$ may be the midpoint of any class. The resulting equation is:

$$\bar{X} = \bar{X}_d + \frac{\Sigma f d}{N} \quad (4)$$

Further simplication is possible by expressing d as d′, the deviation in terms of class intervals, with this result:

$$\bar{X} = \bar{X}_d + \left(\frac{\Sigma f d'}{N}\right) i \quad (5)$$

These will not be calculated here but may be obtained from a consideration of Table 3. $\bar{X}$ calculated by equation (4) and (5) will check the value $\bar{X}$ from equations (2) and (3).

Two important features of the arithmetic mean should be considered here: — a) the algebraic sum of the deviations of the individual value from the mean ($\Sigma x = 0$); b) The sum of the squares of the deviations (Σx^2) is a minimum. This will be used later in the calculation of standard deviation.

Median

A second common measure of central tendency is the "*Median*", which is the value that divides a distribution so that an equal number of items are on either side of it. It is apparent that the median is easily determined from an array of the data. In Table 2, the median of the distribution of gloss readings is *23*.

Associated with the median are

Gloss Readings		Number of Readings Within Indicated Limits = f
Class	Midpoint	
1-5	3	3
6-10	8	11
11-15	13	13
16-20	18	22
21-25	23	19
26-30	28	14
31-35	33	13
36-40	38	11
41-45	43	4
46-50	48	3
	Total	113 = N

Calculation of Minimum Class Interval i

$$i = \frac{\text{Range}}{1+3.322 \log N} = \frac{46-3}{1+3.322 \log 113}$$

$$i = \frac{43}{1+(3.322)\ (2.053)} = \frac{43}{1+6.83} = \frac{43}{7.83} = 5.5$$

For Ease In Calculation And Representation, i of 5 Units was Chosen, Giving 10 Classes

Table 3. Frequency distribution of gloss readings of 113 white paints.

Gloss Reading	Number of Readings	Percent of Total
1 or more	113	100.0
6 or more	110	97.3
11 or more	99	87.6
16 or more	86	76.1
21 or more	64	56.6
26 or more	45	39.6
31 or more	31	27.4
36 or more	18	15.9
41 or more	7	6.2
46 or more	3	2.7

Table 4. Cumulative frequency distribution of gloss readings of 113 white paints.

the "*quartiles*", which divide the distribution into 4 equal parts. Q_1, the first or lower quartiles, is the value located so that ¼ of the items fall below it and ¾ of the items exceed it. Q_2 is the median; Q_3, the third or upper quartile, is the value so located that ¾ of the items fall below it and ¼ exceed it. For Table 2, the measures are as follows:

$$Q_1 = 16$$
$$Q_2 = 23$$
$$Q_3 = 32$$

Mode

A third measure is the "*Mode*", which is the most frequent value in a distribution—the points around which the items tend to be most heavily concentrated. The mode of distribution of gloss readings (Table 2), is *20*. The modal group or class is, of course, *16-20*, with a midpoint of 18 (Figure 1, Table 3).

All 3 of these measures are drawn in Figure 1. For distributions of this type (which approach "Normality" and are but slightly skewed), Karl Pearson, the eminent statistician has expressed the relationship between the mean, median and mode in this empirical equation:

$$\text{MODE} = \bar{X} - 3\left(\bar{X} - \text{MEDIAN}\right) \qquad (6)$$

Effect of Extreme Values

When skewness (lack of symmetry) is not general but due to a few items deviating a great deal from the mode, the median will only be slightly affected. The arithmetic mean, however, is affected by the value of every item in the series, and the presence of one or a few extremely large (or small) items in a series may result in a mean which is very misleading. As ordinarily computed, the mode is not at all influenced by the presence of a few unusually high (or low) extreme values.

Other Minor Means

Other measures of central tendency which are infrequently used are the geometric and harmonic means.

$$\text{G.M.} = \sqrt[N]{X_1 \cdot X_2 \cdot X_3 \cdots X_N} \qquad (7)$$

GEOMETRIC MEAN

This is sometimes used to average ratios.

$$\text{H.M.} = \frac{1}{\frac{1}{X_1}+\frac{1}{X_2}+\frac{1}{X_3}+\cdots+\frac{1}{X_N}} = \frac{N}{\Sigma \frac{1}{X}} \qquad (8)$$

HARMONIC MEAN

This mean is sometimes used in averaging rates of change.

Spread of a Distribution–Dispersion

We have seen that distributions have a definite central tendency. However, it is also evident that the dispersion of the points or values around their mean can vary greatly. There are several types of measures of dispersions, which are absolute and measured in units of the problem.

Range

This is a rather crude, but useful and easy to understand measure, referring to the lowest and highest value of the distribution. For example, in Table 2, the range is *3 to 46 = 43.* The range has one important disadvantage. Being based on extreme values, it is misleading if one or both of these values is an unusual occurrence.

Average Deviation

This is the sum of the deviation of the items from the arithmetic mean, without regard to sign, divided by the number of items. Thus:

$$\text{A.D} = \frac{\Sigma |X|}{N} \qquad (9)$$

OR FOR A FREQUENCY DISTRIBUTION

$$\text{A.D.} = \frac{\Sigma f |X|}{N} \qquad (10)$$

Where | | means the signs are neglected.

For a normal distribution (symmetrical) 57.5% of the items are included within the range $\overline{X} \pm \text{A.D.}$

Quartile Deviation

This measure of dispersion is based on the lower and upper quartiles, Q_1 and Q_3 as is given by the following expression:

$$Q = \frac{Q_3 - Q_1}{2} \qquad (11)$$

For a symmetrical series, or one nearly so $\overline{X} \pm Q$, will include 50% of the values. Data from Table 2, shows Q to be $\frac{32-16}{2} = 8.$

Also, from Table 2, $\overline{X} \pm Q = 23.7 \pm 8 = 15.7-31.7$. Of the 113 items, 60 are in this range, or 53.1%.

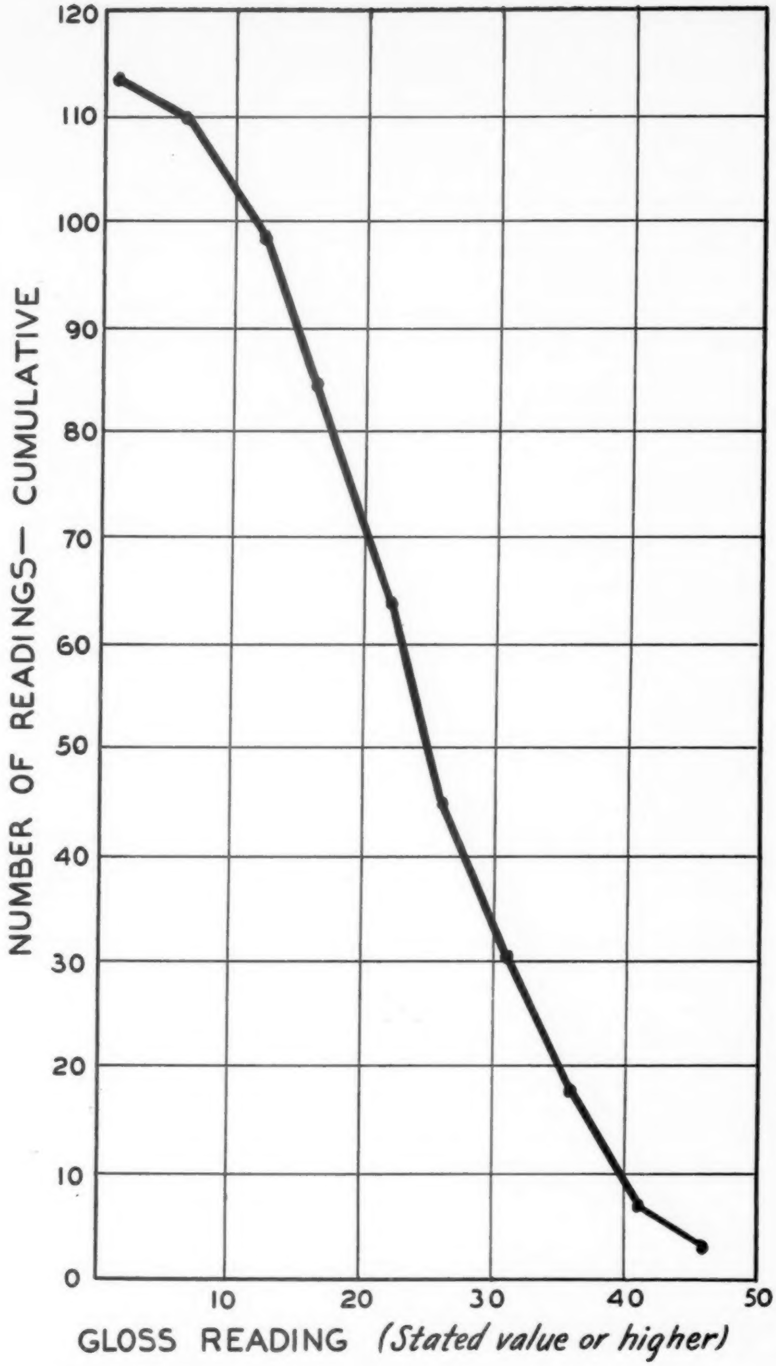


Figure 2. Gloss readings of 113 white paints. Cumulative frequency distribution curve—Ogive—Absolute data.

Standard Deviation

This is one of the most important and critical measures in all of statistics, and one which will enter into almost all of our considerations for the rest of this paper. It is represented by the Greek letter σ (or sometimes as S.D.).

The standard deviation (or root-mean-square deviation as it is sometimes known) is obtained as follows:

$$\sigma = \sqrt{\frac{\Sigma (X-\overline{X})^2}{N}} = \sqrt{\frac{\Sigma X^2}{N}} \qquad (12)$$

The steps involved in the actual calculation of σ from raw data are

as follows:

(1) Determine the deviation x of each item from $\overline{X}$
(2) Square these deviations
(3) Total them
(4) Divide this sum by N
(5) Take the square root.

For a large number of readings, this could become very laborious and tedious. A short cut computation for σ is:

$$\sigma = \sqrt{\frac{\Sigma X^2}{N} - \left(\frac{\Sigma X}{N}\right)^2} \qquad (13)$$

This compilation has been performed in Table 1, with the following results

$$\sigma = \sqrt{\frac{75{,}721}{113} - \left(\frac{2677}{113}\right)^2} =$$

$$\sqrt{670.1 - 561.7} = \sqrt{108.4} = 10.41$$

For grouped data, in a frequency distribution,

$$\sigma = \sqrt{\frac{\Sigma f X^2}{N}} \qquad (14)$$

Short cut methods include the following:

$$\sigma = \sqrt{\frac{\Sigma f d^2}{N} - \left(\frac{\Sigma f d}{N}\right)^2} \qquad (15)$$

OR

$$\sigma = i\sqrt{\frac{\Sigma f (d')^2}{N} - \left(\frac{\Sigma f d'}{N}\right)^2} \qquad (16)$$

These have not been computed here, but may be readily calculated from Table 3.

Several important properties and uses of the standard deviation are:

(1) It is affected by all values.
(2) A great importance is given to extreme values (since deviations are squared)
(3) It is one of the factors involved in the equations for normal and skewed curves
(4) It is invaluable in reliability testing and correlation analysis.

The standard deviation is a much used measure of the spread of a series of data. For a normal distribution, 68.27% of the values are included within the range $\overline{X} \pm \sigma$, 95.45% within $\overline{X} \pm 2\sigma$ and 99.73% within $\overline{X} \pm 3\sigma$.

This is shown in Figure *4*.

Referring to Table 2 and 3, with $\sigma = 10.41$, $\overline{X} \pm \sigma = 23.70 \pm 10.41 = 13.29 - 34.11$. Within this range

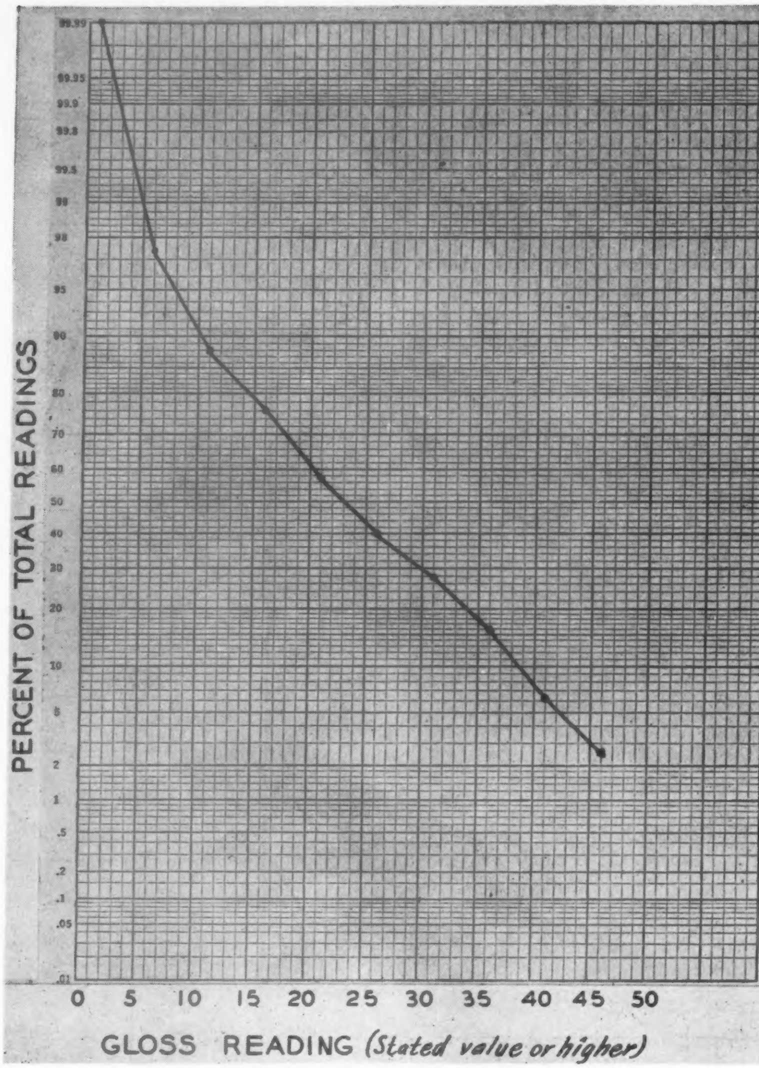


Figure 3. Gloss readings of 113 white paints—Cumulative frequency distribution curve—Ogive—Percentages.

are *75* items or 66.4%. For $\overline{X} \pm 2\sigma$, $23.70 \pm 20.82 = 2.88 - 44.52$, there are 110 items within this range, or 97.4%. Finally, for $\overline{X} \pm 3\sigma$, $23.70 \pm 31.23 = 0 - 54.93$, there are 113 or 100% of the items within this range. This is only a fair to poor check of the values shown above, and indicates what has been evident all along—that our data is not normally or symmetrically distributed.

Coefficient of Variation

This is one more measure of dispersion—but of relative, rather than absolute dispersion. It is given by:

$$V = \frac{\sigma}{\overline{X}} \qquad (17)$$

This concept is of value in comparing series having different means or that are expressed in different units.

Types of Distributions

Normal Curve

A frequency distribution usually represents a sample drawn from a much larger population or universe. Even though a sample is composed of but a few hundred or a few score items, it may be reasonable representative of the larger universe from which it was drawn. Since it is virtually never possible to measure all of the individuals or items comprising a universe, we must form our notion of the larger group from a study of a sample. We may therefore fit any one of a number of types of

curves to a frequency distribution in order to attempt to describe what appears to be the general form of the curve for the entire population.

For our purpose, we will discuss mainly the "normal curve", and mention other types in passing (21).

The concept of the normal curve appears to have been originally developed by Abraham De Moivre and explained in a mathematical treatise which its author believed had no practical applications other than as a solution of problems encountered in games of chance. Gauss later used the curve to describe the theory of accidental errors of measurements involved in the calculation of orbits of heavenly bodies. Because of Gauss' work this curve is sometimes referred to as the "Gaussian curve".

In fitting a normal curve it is assumed that only chance errors are present and that the arithmetic mean represents the best approximation of the true value. It will be observed (Figure 4):

(1) that small errors are more frequent than large ones
(2) that very large errors are unlikely to occur
(3) that positive and negative errors of the same numerical magnitude are equally likely to occur—in other words—the curve is symmetrical.

Because the fitted curve represents the relationship between the magnitude of an error and the probability of its occurrence in a given series of measurements, it is frequently termed the "normal probability curve" or simply the "normal" curve.

The equation of the normal curve is:

$$Y_c = \frac{Ni}{\sigma\sqrt{2\pi}} e^{\frac{-x^2}{2\sigma^2}} \quad (18)$$

where Y_c = the computed height of an ordinate at the distance x from the arithmetic mean. The other variables have been shown previously.

Figure 4 shows a normal curve fitted to the data of Table 3. The frequency distribution curve of Figure 1 is superimposed on Figure 4 to show their relationships.

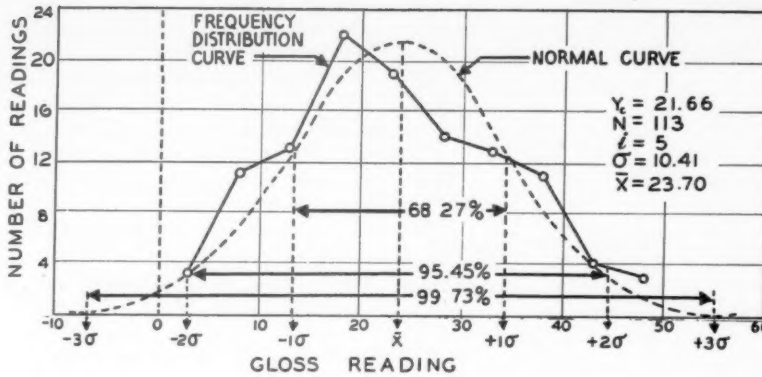


Figure 4. Normal curve fitted to data of gloss readings of 113 white paints.

It is obvious that the data of Tables 1 and 3 are not distributed according to the normal curve. This was brought out further by the non-linear ogive of Figure 3.

Skewness

Figure 1, then, represents an asymmetrical or "skewed" curve. The skewness is referred to in the direction of the extreme values, or speaking in terms of the curve, in the direction of the excess tail. It is skewed positively or to the right.

Pearson's quantitative measure of skewness is:

$$\text{SKEWNESS} = \frac{3(\bar{X} - \text{Med})}{\sigma} \quad (19)$$

For the curve in Figure 1,

$$\text{SK} = \frac{3(23.70 - 23.0)}{10.41} = +0.202$$

Another measure of skewness is the so-called third moment about the mean, π_3. (σ^2 is the second moment, π_2).

$$\pi_3 = \frac{\Sigma x^3}{N} \quad (20)$$

Both Sk and π_3 are zero for normal curves.

Kurtosis

A measure of the peakedness or flatness of a frequency distribution curve. Curves of this type are shown in Figure 5, compared to a normal curve. The more peaked curves are called "leptokurtic" and the flat-topped curves are called "platykurtic".

An absolute measure of kurtosis is given by the fourth moment about the mean, π_4.

$$\pi_4 = \frac{\Sigma x^4}{N} \quad (21)$$

This may be put on a relative

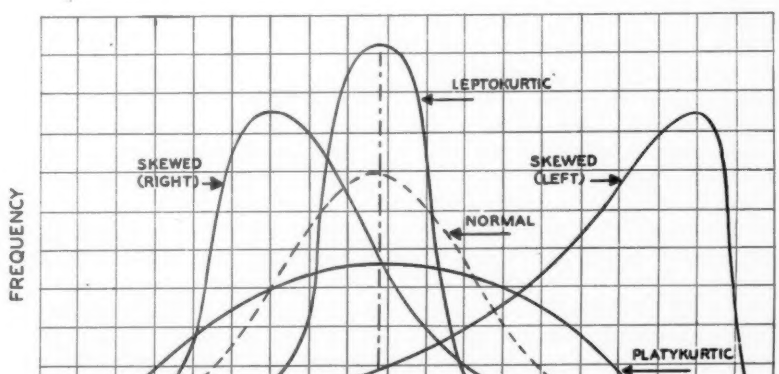


Figure 5. Types of non-normal curves.

basis by dividing by σ^4(or π_2^2) thus:

$$\alpha_4 \text{ (or } B_2) = \frac{\pi_4}{\sigma^4} = \frac{\pi_4}{\pi_2^2} \qquad (22)$$

α_4 = for a normal curve. For a flat-topped curve, $\alpha_4 < 3.0$. For a peaked curve, $\alpha_4 > 3.0$.

Open End

This refers to a special case where the limits of the first or last class in a frequency distribution are indefinite or undefined, such as "greater than 65. . ."

Multimodal

A distribution with 2 or more peaks (or modes).

Other Types of Non-Normality

Hyperbolic, Parabolic, Exponential, Logarithmic. These pertain to data which is distributed according to mathematical relationships (known or unknown) which differ from the normal equation (18). Examples of these are growth curves.

Although most actual distributions are not normal in nature, we will for the greater part consider normal distributions in this paper for the purposes of simplification. Quite often, unless a distribution is tremendously skewed, assumptions of normality give acceptable results.

Important Considerations

The concepts we have discussed are basic to the understanding and appreciation of the statistical approach. However, these must be examined together with several other fundamental considerations before we may proceed to statistical designs applicable to the coatings industry.

Population—Universe

First among these is a consideration of the population or universe of values from which one or several sets of samples are drawn for examination. As previously stated, since we can not actually measure the whole population of values—say the iodine value of every gram of linseed oil in a 5 car shipment, we must substitute readings on a series of samples for the prediction of the iodine value of the shipment.

The iodine value predicted will approach the "true value" for the shipment to an extent governed by the type and scope of the sampling procedures and by the actual uniformity of the shipment.

Probability

The concept of probability is continually used in statistics and its meaning and importance should be firmly established. It may be defined as follows: if an event may happen in A ways, and fail to happen in B ways, and all of these ways are mutually exclusive (that is uncorrelated or independent of each other) and equally likely to occur—the *probability* of the event happening is:

$$p = \frac{A}{A + B}$$

or A chances of success in A + B total trials.

A simple example for clarification is: the probability of choosing an off-specification drum of fatty acid in 1 drum samples from a shipment of 60 drums containing 3 off-standard drums located at random in the group—this probability is 3 in 60 or 1 chance in 20.

Probability may also be considered as relative frequency of occurrence in the long run. Thus:

$$p = \text{LIMIT} \left(\frac{f}{f_{TOT}} \right)_{f_{TOT} \longrightarrow \infty}$$

OR

$$p = \underset{N \longrightarrow \infty}{\text{LIMIT}} \left(\frac{f}{N} \right) \qquad (23)$$

This is quite useful when considering areas under a frequency distribution curve, as shown in Figure 4. Here, it is shown that 99.73% of all the values are included in the range $\overline{X} \pm 3\sigma$. Therefore in a set of values that is distributed normally, the probability of any individual value being in the range of $\overline{X} \pm 3\sigma$ is 99.73 chances in 100. Similarly for the $\overline{X} \pm 2\sigma$ and the $\overline{X} \pm 1\sigma$ ranges.

Most statistical tables are similarly based in that they show the relationship of the probability of occurrence of a particular variable or concept, (as measured by areas under curves) with distances along the abscissas of these curves (usually in units of σ).

Significance Levels

In our further study of significance of differences we shall consider the significance of the difference between a sample value and an assumed population value, and the significance of the difference between two sample values. The procedure for testing the significance of the difference may be summarized into three steps (21):

(1) Set up the hypothesis that the true difference is zero (i.e., the samples have been drawn from the same population)

(2) Upon the basis of this hypothesis, determine the probability that such a difference as the one observed might occur because of sampling variations.

(3) Draw a conclusion concerning the reasonableness of the hypothesis.

If such an observed difference could hardly have occurred by chance, we have cast much doubt upon the hypothesis of (1). We therefore abandon the hypothesis and conclude that the observed difference is significant. However, if such an observed difference could very often occur because of chance, we have cast very little doubt upon the hypothesis. We therefore continue to regard the hypothesis as tenable and conclude that the difference is not significant.

The question will arise as to what level of probability we shall choose to decide for or against our null hypothesis. Some authorities prefer the criterion of 5 chances out of 100—the 5% or 0.05 level of significance. Others insist on a 1% level. Perhaps most satisfactory of all is to ascertain that an observed sample mean might occur because of chance, and then to decide whether or not the probability is small enough for the particular problem at hand. Critical probability levels should be lowest for tests of events or properties whose failures could be tragic or extremely costly.

Degrees of Freedom

We are almost always dealing with samples—both small and large—and not with infinite parent populations. Our estimates of population means and dispersions will always be subject to error, dependent in part on sample size.

Also, the mere calculation of sample average, $\overline{X}$, and its further use in statistical analysis, restricts the data. When the arithmetic mean is computed, one "*degree of freedom*" is lost, since the value of

any one of the items is defined by knowledge of the value of the mean and of the remaining items. In other words, if for a series of items the sole requirement set up is that $\Sigma x = 0$ (that is, the mean has been determined), the values of all of the other items save one may be arbitrarily set down; all but one are "free to vary". The value of the other item is determined by the above requirement. In more general language, the number of degrees of freedom is the number of deviations (items or N) minus the number of constants determined from the sample and used to fix the points from which those deviations are measured. The use of N-1 in the above expression is particularly important when N is small. When N is large, it matters little whether we divide by N or N-1 (23).

The rule that the "number of degrees of freedom allotted to error is one less than the number of measurements" does not hold generally. In fact it applies only when the fixed "true" value is the only systematic effect in the data. Usually, in experimental work, several "true" values are built into the experiment. Each will require a degree of freedom and only the remaining degrees of freedom can be used to display the effects of error alone. (5)

Therefore, when the expression "degrees of freedom" is used, it must be recognized that the full meaning is "the number of degrees of freedom of a set of measurements available for estimating error".

It will be seen that considerations of degrees of freedom is quite important in such tests as analysis of variance and linear regression, since useful results can only be computed when the proper restrictions are placed on the data.

Reliability, Significance—"t" Tests

The comparison of averages of sample sets is an everyday occurrence. If statistics did no more than show how to systematically compare these averages, it would make an important contribution. It goes beyond, however, and provides the techniques which demonstrate how averages and variations of all types of data can be compared, quickly and effectively—with clearly stated "confidence limits."

Standard Deviation of the Universe

Assume the existence of an infinite number of paints for which gloss readings have been obtained from time minus infinity to the present. This distribution of data will have an average X' and a standard deviation σ'. Since σ' can never actually be measured, we attempt to estimate it by sampling from the parent universe. For a sample of N, our estimate of σ' is given by:

$$\sigma'_{EST} = \sqrt{\frac{\Sigma(x-\bar{x})^2}{N-1}} = \sqrt{\frac{\Sigma(x-\bar{x})^2}{D.\ F}} = \sigma\sqrt{\frac{N}{N-1}} \qquad (24)$$

As N ∞, as the sample size gets greater, σ'est (and σ)$\rightarrow\sigma'$—the true dispersion of the universe.

Standard Deviation of the Average

As we proceed to take sets of N samples each from the parent universe, we notice that the standard deviations of the averages so obtained are considerably less than the individual standard deviations. This relationship is:

$$\sigma_{\bar{x}} = \frac{\sigma'}{\sqrt{N}} \text{ OR } \frac{\sigma'_{EST}}{\sqrt{N}} \qquad (25)$$

If the distribution is not exactly normal, the distribution of means of random samples tends to normality, as the size of each sample is increased.

Standard Deviation of the Standard Deviation

For small samples, deviation of sets of samples from a universe is:

$$\sigma_{\sigma} = \frac{\sigma'}{\sqrt{2N}} \qquad (26)$$

This relationship is useful for checking reproducibility of precision from one test to another.

Difference of Means—Large Samples

Tests were made of a sample of 30 bags of white lead chosen at random from a series of shipments totalling 1000 bags. The quality characteristic examined was tinting strength, which for the previous shipments had averaged 176. The 30 bag sample had an average tinting strength of 180, with a standard deviation of 8.0 units. Was this sample representative of former shipments—or was there a significant difference between them?

Here H_o = the null hypothesis is that there is no significant difference between $\bar{X}' = 176$ for the population—and $\bar{X} = 180$ and $\sigma = 8.0$ for the sample. Therefore we hypothesize that the true difference between $\bar{X}'$ and $\bar{X}$ is zero (they are equal) and we determine what the probability is that their difference might be as much as 4.0 units of tinting strength due to chance alone.

An estimate of the standard deviation of the universe is first obtained:

$$\sigma'_{EST} = \sigma\sqrt{\frac{N}{N-1}} = 8.0\sqrt{\frac{30}{29}} = 8.13$$

Then we estimate the standard deviation of means of 30 samples from this universe, thus:

$$\sigma_{\bar{x}} = \frac{\sigma'_{EST.}}{\sqrt{N}} = \sqrt{\frac{8.13}{\sqrt{30}}} = 1\ 484$$

We then proceed to express the observed difference between means in terms of the standard deviation of the mean by making the following ratio:

$$\frac{\bar{X}'-\bar{X}}{\sigma_{\bar{x}}} = \frac{x}{\sigma_{\bar{x}}} = \frac{4.0}{1.484} = 2.70$$

(This assumes that the sampling distribution of $\frac{\bar{X}'-\bar{X}}{\sigma_{\bar{x}}}$ is normal, which is essentially true when N is large, but not when N is small).

Table 5 is the tabulation of areas under the normal curve as a function of $\frac{X-\bar{X}}{\sigma}$ or $\frac{X}{\sigma}$ For $\frac{X}{\sigma} = 2.7$, the cross hatched area in Table 5 is equal to 0.4965. (The total area under the curve = 1.0—which is a summation of all probabilities—or frequencies—involved) (26).

This means that 49.65 out of 100 samples would fall between $\bar{X}'-\bar{X} = 0$ and $\bar{X}'-\bar{X} = +4.0$ and consequently $0.5000-0.4965$ (since 0.5000 is ½ the area under the normal curve) or 0.35 sample in 100 would occur beyond +4.0.

If the means were identical, we would get a difference as large as +4.0 units only 0.35% of the time.

Since this is considerably below both of the usual acceptance levels (5% and 1%), we have shown the means to be statistically dissimilar and have thus rejected the null hypothesis.

Difference of Means—Small Samples

The solution of this problem for small samples is a great landmark in the development of statistical methods. It was accomplished in 1908 by the English chemist, W. S. Gosset, who wrote under the name of "Student" (5).

Student devised a statistic—"t"—and a table called the "t" table (Table 6). This gives for various degrees of freedom, the probability of exceeding the listed limiting values of "t" if sample sets tested come from the same population and show differences which are due to chance causes (26).

$$t = \frac{\bar{X}_1 - \bar{X}'}{\sigma_{\bar{X}}} \qquad (27)$$

Several examples will illustrate the use of the "t" tables:

Example (1)—An established method for running acid values has given a population mean of 0.230. A new method has been developed—and checked on 16 samples, with an $\bar{X} = 0.250$ and a $\sigma = 0.080$. Are the 2 methods significantly different?

Again, the null hypothesis is that there is no significant difference in the methods.

$\bar{X}' = 0.230 \qquad \sigma_{EST} = 0.080\sqrt{\frac{16}{15}} = 0.0824$

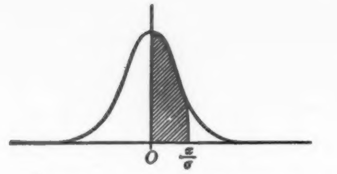
$N = 16 \qquad \sigma_{\bar{x}} = \frac{0.0826}{\sqrt{16}} = \frac{0.0824}{4} = 0.0206$

$$t = \frac{\bar{x}' - \bar{x}}{\sigma_{\bar{x}}} = \frac{0.250 - 0.230}{0.0206} = \frac{0.020}{0.0206} = 0.97$$

Referring to Table 6, for D.F. = 16−1 = 15, the probability of t = 0.866 being exceeded due to chance alone is p = 0.2. For t = 1.341, p = 0.1. Therefore the probability that the difference in means in due to chance causes alone—and not any bias or assignable causes—is about 0.17 or 17 chances in 100. This figure is well above the 5% limit and so we accept our null hypothesis.

For increased facility in interpolating probability values, the data of Table 6 has been graphed in Figure 6. According to Figure 6, the probability for Example (1) is 0.18.

Example (2)—Test method A for



NORMAL DISTRIBUTION AREAS

$\frac{x}{\sigma}$	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0159	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2518	0.2549
0.7	0.2580	0.2612	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3718	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4083	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4430	0.4441
1.6	0.4452	0.4463	0.4474	0.4485	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4758	0.4762	0.4767
2.0	0.4773	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4865	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4980	0.4980	0.4981
2.9	0.4981	0.4982	0.4983	0.4984	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.49865	0.4987	0.4987	0.4988	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990
3.1	0.49903	0.4991	0.4991	0.4991	0.4992	0.4992	0.4992	0.4992	0.4993	0.4993
3.2	0.4993129									
3.3	0.4995166									
3.4	0.4996631									
3.5	0.4997674									
3.6	0.4998409									
3.7	0.4998922									
3.8	0.4999277									
3.9	0.4999519									
4.0	0.4999683									
4.5	0.4999966									
5.0	0.4999997133									

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Table 5.

rosin acid determination—using an indicator for the endpoint—gives the following results on 8 standard samples as compared to Test Method B—using potentiometric titration on 6 of the same standard samples:

$\bar{X}_A = 4.83 \qquad \bar{X}_B = 4.06$

$\sigma_A = 0.95 \qquad \sigma_B = 0.86$

$N_A = 8 \qquad N_B = 6$

Do these two test methods give statistically equivalent results? The null hypothesis says that $E(\bar{X}_A - \bar{X}_B) = 0$. (E = Expected value)

Here, we must determine the standard deviation of the difference of the means; therefore Equation (27) for this case is rewritten as:

$$t = \frac{\bar{X}_A - \bar{X}_B - 0}{\sigma_{\bar{X}_A - \bar{X}_B}} \qquad (28)$$

$$\sigma'_{EST\ A} = 0.95\sqrt{\tfrac{8}{7}} = 1.015$$

$$\sigma_{\bar{X}_A} = \frac{1.015}{\sqrt{8}} = 0.359$$

$$\sigma'_{EST\ B} = 0.86\sqrt{\tfrac{6}{5}} = 0.941$$

$$\sigma_{\bar{X}_B} = \frac{0.941}{\sqrt{6}} = 0.385$$

The standard error of the difference of 2 means is given by:

$$\sigma_{\bar{X}_A - \bar{X}_B} = \sqrt{(\sigma_{\bar{X}_A})^2 + (\sigma_{\bar{X}_B})^2} \qquad (29)$$

$$= \sqrt{(0.359)^2 + (0.385)^2} = \sqrt{0.129 + 0.148} = \sqrt{0.277} = 0.527$$

$$\text{THEN: } t = \frac{4.83 - 4.06}{0.527} = \frac{0.77}{0.527} = 1.46$$

In this case, degrees of freedom $= (N_A - 1) + (N_B - 1)$ or D.F. $= (8-1) + (6-1) = 7 + 5 = 12$.

For $t = 1.46$ and D.F. $= 12$, Figure 6 shows a probability equal to 0.09 or 9 times in 100 that this difference in means could have been caused by chance variations. The null hypothesis is again upheld.

In Example (2), for utmost precision in a case where N_A is not equal to N_B and both N's are small, the following relationship should more properly be used to weight the 2 standard deviations by their respective degrees of freedom to determine $\sigma\bar{X}_A - \bar{X}_B$ (21).

$$\sigma_{\bar{X}_A - \bar{X}_B} = \sqrt{\frac{(N_A + N_B)\left[\Sigma(x_A - \bar{X}_A)^2 + \Sigma(x_B - \bar{X}_B)^2\right]}{N_A N_B\left[(N_A - 1) + (N_B - 1)\right]}} \qquad (30)$$

However, for the sake of simplicity, Equation (29) will be used; although we recognize that we are not on quite as solid ground for extremely small values of N.

The "t" test is extremely valuable and will be used several times during this paper. As a matter of interest, it is readily apparent that the "t" function for D.F. $= \infty$, approaches the same value as the normal curve.

Confidence Limits

In Example (1) above, consider a series of samples from the same population. We may say that we can state the means of each of these samples with a known precision. However, how close do the means that we calculate actually approach the true mean of the universe or even agree with each other?

We can estimate this agreement by examination of the form of the "t" test.

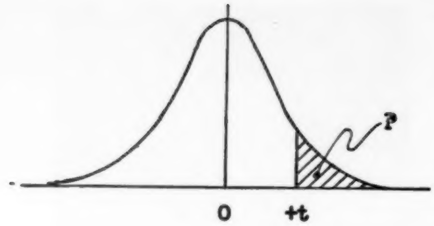
$$t = \frac{\bar{X}' - \bar{X}}{\sigma_{\bar{X}}} = \frac{d}{0.0206}$$

for $\bar{X} = 0.250$ and D.F. $= 15$

Let $\bar{X}' - \bar{X} = d$, which is a difference that will yield a value of $t = 2.131$ corresponding to a $p = 0.025$. (Since Table 6 shows single tail areas of t, p should be doubled or $p = 0.05$ for the whole distribution area.) Thus

$$2.131 = \frac{d}{0.0206} \text{ or } d = 0.0439$$

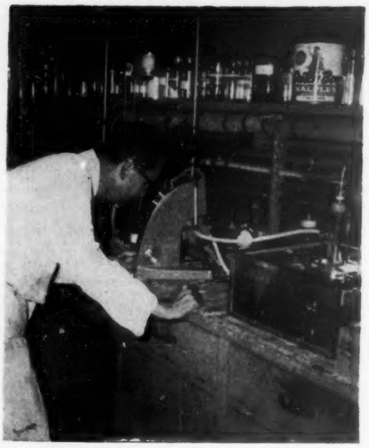
This relationship can now be restated as follows: The probability of a mean from a large



DF	Probability.							
	·4	·2	·1	·05	·025	·01	·005	·0005
1	·325	1·376	3·078	6·314	12·706	31·821	63·657	636·619
2	·289	1·061	1·886	2·920	4·303	6·965	9·925	31·598
3	·277	·978	1·638	2·353	3·182	4·541	5·841	12·941
4	·271	·941	1·533	2·132	2·776	3·747	4·604	8·610
5	·267	·920	1·476	2·015	2·571	3·365	4·032	6·859
6	·265	·906	1·440	1·943	2·447	3·143	3·707	5·959
7	·263	·896	1·415	1·895	2·365	2·998	3·499	5·405
8	·262	·889	1·397	1·860	2·306	2·896	3·355	5·041
9	·261	·883	1·383	1·833	2·262	2·821	3·250	4·781
10	·260	·879	1·372	1·812	2·228	2·764	3·169	4·587
11	·260	·876	1·363	1·796	2·201	2·718	3·106	4·437
12	·259	·873	1·356	1·782	2·179	2·681	3·055	4·318
13	·259	·870	1·350	1·771	2·160	2·650	3·012	4·221
14	·258	·868	1·345	1·761	2·145	2·624	2·977	4·140
15	·258	·866	1·341	1·753	2·131	2·602	2·947	4·073
16	·258	·865	1·337	1·746	2·120	2·583	2·921	4·015
17	·257	·863	1·333	1·740	2·110	2·567	2·898	3·965
18	·257	·862	1·330	1·734	2·101	2·552	2·878	3·922
19	·257	·861	1·328	1·729	2·093	2·539	2·861	3·883
20	·257	·860	1·325	1·725	2·086	2·528	2·845	3·850
21	·257	·859	1·323	1·721	2·080	2·518	2·831	3·819
22	·256	·858	1·321	1·717	2·074	2·508	2·819	3·792
23	·256	·858	1·319	1·714	2·069	2·500	2·807	3·767
24	·256	·857	1·318	1·711	2·064	2·492	2·797	3·745
25	·256	·856	1·316	1·708	2·060	2·485	2·787	3·725
26	·256	·856	1·315	1·706	2·056	2·479	2·779	3·707
27	·256	·855	1·314	1·703	2·052	2·473	2·771	3·690
28	·256	·855	1·313	1·701	2·048	2·467	2·763	3·674
29	·256	·854	1·311	1·699	2·045	2·462	2·756	3·659
30	·256	·854	1·310	1·697	2·042	2·457	2·750	3·646
40	·255	·851	1·303	1·684	2·021	2·423	2·704	3·551
60	·254	·848	1·296	1·671	2·000	2·390	2·660	3·460
120	·254	·845	1·289	1·658	1·980	2·358	2·617	3·373
∞	·253	·842	1·282	1·645	1·960	2·326	2·576	3·291

Adapted and abridged from Fisher & Yates: Statistical Tables for Biological, Agriculture and Medical Research;" Oliver and Boyd, London, 1943.

Table 6. Distribution of Student "t" (single tail area).



Laboratory technician reading the refractive index of alkyd resin solution for correlating refractive index and non-volatile content.

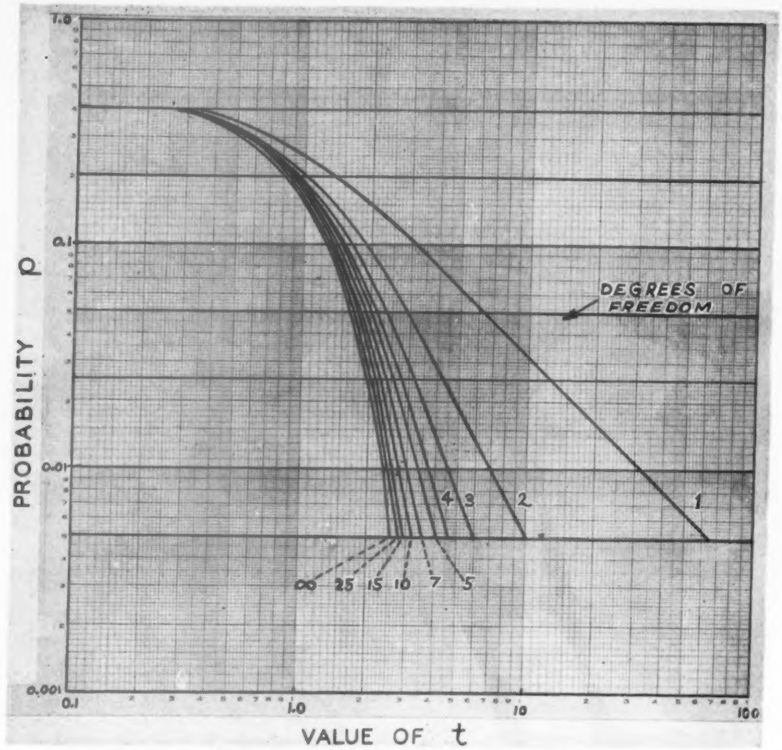


Figure 6. Student "t" Distribution—Probability curves.

series of such tests falling in the range of $\overline{X} \pm d$ or 0.250 ± 0.044 (or $0.206-0.294$) is 95 in 100 or *95%*. $(1.00-0.05)$. Thus a prediction has been made regarding the "*Confidence Limits*" (or fiducial limits) within which the mean would lie if based on a very large number of experiments.

The "95% Confidence Limits" calculated are very commonly used as an expression of the degree of confidence which the statistician or experimenter has in his conclusions. Other confidence limits for other percentages are easily calculated in a similar manner.

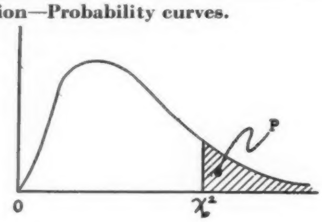
It is interesting to note that Figure 4 shows confidence limits for normal curve areas—corresponding to $\overline{X} \pm 1$, 2 and 3 σ.

Reliability of Measures of Dispersion

Sample Standard Deviation

The reliability of a sample σ (or difference between 2 sample sigmas) may be tested in a manner analogous to that used for means—but using Equation (26) for σ_σ. For large samples $(N > 30)$, a t test based on σ_σ will be used and areas under the normal curve or from the Student t distribution may be used, depending on the number of degrees of freedom. (Usually Figure 6 will be satisfactory.)

However for small values of N (under 30), the use of σ_σ is not valid since the distribution of σ_σ is highly skewed for $N < 30$.



DISTRIBUTION OF CHI SQUARE

DF	Probability. ·99	·98	·95	·90	·80	·70	·50	·30	·20	·10	·05	·02	·01	·001
1	·0³157	·0³628	·00393	·0158	·0642	148	·455	1·074	1·642	2·706	3·841	5·412	6·635	10·827
2	·0201	·0404	·103	211	·446	·713	1·386	2·408	3·219	4·605	5·991	7·824	9·210	13·815
3	·115	·185	·352	·584	1·005	1·424	2·366	3·665	4·642	6·251	7·815	9·837	11·341	16·268
4	·297	·429	·711	1·064	1·649	2·195	3·357	4·878	5·989	7·779	9·488	11·668	13·277	18·465
5	554	·752	1·145	1·610	2·343	3·000	4·351	6·064	7·289	9·236	11·070	13·388	15·086	20·517
6	·872	1·134	1·635	2·204	3·070	3·828	5·348	7·231	8·558	10·645	12·592	15·033	16·812	22·457
7	1·239	1·564	2·167	2·833	3·822	4·671	6·346	8·383	9·803	12·017	14·067	16·622	18·475	24·322
8	1·646	2·032	2·733	3·490	4·594	5·527	7·344	9·524	11·030	13·362	15·507	18·168	20·090	26·125
9	2·088	2·532	3·325	4·168	5·380	6·393	8·343	10·656	12·242	14·684	16·919	19·679	21·666	27·877
10	2·558	3·059	3·940	4·865	6·179	7·267	9·342	11·781	13·442	15·987	18·307	21·161	23·209	29·588
11	3·053	3·609	4·575	5·578	6·989	8·148	10·341	12·899	14·631	17·275	19·675	22·618	24·725	31·264
12	3·571	4·178	5·226	6·304	7·807	9·034	11·340	14·011	15·812	18·549	21·026	24·054	26·217	32·909
13	4·107	4·765	5·892	7·042	8·634	9·926	12·340	15·119	16·985	19·812	22·362	25·472	27·688	34·528
14	4·660	5·368	6·571	7·790	9·467	10·821	13·339	16·222	18·151	21·064	23·685	26·873	29·141	36·123
15	5·229	5·985	7·261	8·547	10·307	11·721	14·339	17·322	19·311	22·307	24·996	28·259	30·578	37·697
16	5·812	6·614	7·962	9·312	11·152	12·624	15·338	18·418	20·465	23·542	26·296	29·633	32·000	39·252
17	6·408	7·255	8·672	10·085	12·002	13·531	16·338	19·511	21·615	24·769	27·587	30·995	33·409	40·790
18	7·015	7·906	9·390	10·865	12·857	14·440	17·338	20·601	22·760	25·989	28·869	32·346	34·805	42·312
19	7·633	8·567	10·117	11·651	13·716	15·352	18·338	21·689	23·900	27·204	30·144	33·687	36·191	43·820
20	8·260	9·237	10·851	12·443	14·578	16·266	19·337	22·775	25·038	28·412	31·410	35·020	37·566	45·315
21	8·897	9·915	11·591	13·240	15·445	17·182	20·337	23·858	26·171	29·615	32·671	36·343	38·932	46·797
22	9·542	10·600	12·338	14·041	16·314	18·101	21·337	24·939	27·301	30·813	33·924	37·659	40·289	48·268
23	10·196	11·293	13·091	14·848	17·187	19·021	22·337	26·018	28·429	32·007	35·172	38·968	41·638	49·728
24	10·856	11·992	13·848	15·659	18·062	19·943	23·337	27·096	29·553	33·196	36·415	40·270	42·980	51·179
25	11·524	12·697	14·611	16·473	18·940	20·867	24·337	28·172	30·675	34·382	37·652	41·566	44·314	52·620
26	12·198	13·409	15·379	17 292	19·820	21·792	25·336	29·246	31·795	35·563	38·885	42·856	45·642	54·052
27	12·879	14·125	16·151	18 114	20·703	22·719	26·336	30·319	32·912	36·741	40·113	44·140	46·963	55·476
28	13·565	14·847	16·928	18·939	21·588	23·647	27·336	31·391	34·027	37·916	41·337	45·419	48·278	56·893
29	14·256	15·574	17·708	19·768	22·475	24·577	28·336	32·461	35·139	39·087	42·557	46·693	49·588	58·302
30	14·953	16·306	18·493	20·599	23·364	25·508	29·336	33·530	36·250	40·256	43·773	47·962	50·892	59·703

Table 7. *From Fisher & Yates: "Statistical Tables from Biological, Agricultural and Medical Research;" Oliver and Boyd, London, 1943.*

Chi Square

For small samples, we may use a statistic called "Chi Square"—or χ^2. The distribution of sample values of σ or actually the *variance* $-\sigma^2$—may be put in the form:

$$\chi^2 = \frac{N\sigma^2}{(\sigma')^2} \qquad (31)$$

where the distribution of the population is assumed to be normal. The distribution of the Chi square function has been determined in the usual form of a probability—degrees of freedom relationship and is shown as Table 7.

Using this relationship (Equation 31) and Table 7, we may determine confidence limits for samples of sigmas from a population with a known σ'—or conversely, we may determine limits within which σ' may confidently be expected to fall if we know σ (as is more usually the case.)

Paint laboratory technician is shown calculating an analysis of variance. Computation is done by a mechanical calculator within a matter of minutes.

z—Variance Ratio

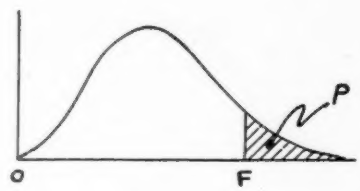
The square of the standard deviation, σ^2, the *variance* (or *mean square*) is a most valuable concept and will be used a great deal in all that follows.

For testing the significance of the difference between 2 standard deviations (or variances, say σ_1^2 and σ_2^2) when N_1 and N_2 are small and not equal to each other, R. A. Fisher—the father of modern statistical methods—suggested a transformation, thus:

$$z = \ln\frac{\sigma_1}{\sigma_2} = \frac{1}{2}\ln\frac{\sigma_1^2}{\sigma_2^2} = 1.15729\log\frac{\sigma_1^2}{\sigma_2^2} \qquad (32)$$

where $\sigma_1 > \sigma_2$ (to make z positive).

Tables of z exist; the significance of the difference of 2 sigmas would



DISTRIBUTION OF VARIANCE RATIO, F

Values of DF_2	Values of DF_1, the number of degrees of freedom of the greater variance: 1		2		3		4		5		6		7		8		10		12		16		20		30		50		100		∞		Values of DF_2
P→	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	
1	161	4,052	200	4,999	216	5,403	225	5,625	230	5,764	234	5,859	237	5,928	239	5,981	242	6,056	244	6,106	246	6,169	248	6,208	250	6,258	252	6,302	253	6,334	254	6,366	1
2	18.51	98.49	19.00	99.01	19.16	99.17	19.25	99.25	19.30	99.30	19.33	99.33	19.36	99.34	19.37	99.36	19.39	99.40	19.41	99.42	19.43	99.44	19.44	99.45	19.46	99.47	19.47	99.48	19.49	99.49	19.50	99.50	2
3	10.13	34.12	9.55	30.81	9.28	29.46	9.12	28.71	9.01	28.24	8.94	27.91	8.88	27.67	8.84	27.49	8.78	27.23	8.74	27.05	8.69	26.83	8.66	26.69	8.62	26.50	8.58	26.35	8.56	26.23	8.53	26.12	3
4	7.71	21.20	6.94	18.00	6.59	16.69	6.39	15.98	6.26	15.52	6.16	15.21	6.09	14.98	6.04	14.80	5.96	14.54	5.91	14.37	5.84	14.15	5.80	14.02	5.74	13.83	5.70	13.69	5.66	13.57	5.63	13.46	4
5	6.61	16.26	5.79	13.27	5.41	12.06	5.19	11.39	5.05	10.97	4.95	10.67	4.88	10.45	4.82	10.27	4.74	10.05	4.68	9.89	4.60	9.68	4.56	9.55	4.50	9.38	4.44	9.24	4.40	9.13	4.36	9.02	5
6	5.99	13.74	5.14	10.92	4.76	9.78	4.53	9.15	4.39	8.75	4.28	8.47	4.21	8.26	4.15	8.10	4.06	7.87	4.00	7.72	3.92	7.52	3.87	7.39	3.81	7.23	3.75	7.09	3.71	6.99	3.67	6.88	6
7	5.59	12.25	4.74	9.55	4.35	8.45	4.12	7.85	3.97	7.46	3.87	7.19	3.79	7.00	3.73	6.84	3.63	6.62	3.57	6.47	3.49	6.27	3.44	6.15	3.38	5.98	3.32	5.85	3.28	5.75	3.23	5.65	7
8	5.32	11.26	4.46	8.65	4.07	7.59	3.84	7.01	3.69	6.63	3.58	6.37	3.50	6.19	3.44	6.03	3.34	5.82	3.28	5.67	3.20	5.48	3.15	5.36	3.08	5.20	3.03	5.06	2.98	4.96	2.93	4.86	8
9	5.12	10.56	4.26	8.02	3.86	6.99	3.63	6.42	3.48	6.06	3.37	5.80	3.29	5.62	3.23	5.47	3.13	5.26	3.07	5.11	2.98	4.92	2.93	4.80	2.86	4.64	2.80	4.51	2.76	4.41	2.71	4.31	9
10	4.96	10.04	4.10	7.56	3.71	6.55	3.48	5.99	3.33	5.64	3.22	5.39	3.14	5.21	3.07	5.06	2.97	4.85	2.91	4.71	2.82	4.52	2.77	4.41	2.70	4.25	2.64	4.12	2.59	4.01	2.54	3.91	10
11	4.84	9.65	3.98	7.20	3.59	6.22	3.36	5.67	3.20	5.32	3.09	5.07	3.01	4.88	2.95	4.74	2.86	4.54	2.79	4.40	2.70	4.21	2.65	4.10	2.57	3.94	2.50	3.80	2.45	3.70	2.40	3.60	11
12	4.75	9.33	3.88	6.93	3.49	5.95	3.26	5.41	3.11	5.06	3.00	4.82	2.92	4.65	2.85	4.50	2.76	4.30	2.69	4.16	2.60	3.98	2.54	3.86	2.46	3.70	2.40	3.56	2.35	3.46	2.30	3.36	12
13	4.67	9.07	3.80	6.70	3.41	5.74	3.18	5.20	3.02	4.86	2.92	4.62	2.84	4.44	2.77	4.30	2.67	4.10	2.60	3.96	2.51	3.78	2.46	3.67	2.38	3.51	2.32	3.37	2.26	3.27	2.21	3.16	13
14	4.60	8.86	3.74	6.51	3.34	5.56	3.11	5.03	2.96	4.69	2.85	4.46	2.77	4.28	2.70	4.14	2.60	3.94	2.53	3.80	2.44	3.62	2.39	3.51	2.31	3.34	2.24	3.21	2.19	3.11	2.13	3.00	14
15	4.54	8.68	3.68	6.36	3.29	5.42	3.06	4.89	2.90	4.56	2.79	4.32	2.70	4.14	2.64	4.00	2.55	3.80	2.48	3.67	2.39	3.48	2.33	3.36	2.25	3.20	2.18	3.07	2.12	2.97	2.07	2.87	15
16	4.49	8.53	3.63	6.23	3.24	5.29	3.01	4.77	2.85	4.44	2.74	4.20	2.66	4.03	2.59	3.89	2.49	3.69	2.42	3.55	2.33	3.37	2.28	3.25	2.20	3.10	2.13	2.96	2.07	2.86	2.01	2.75	16
17	4.45	8.40	3.59	6.11	3.20	5.18	2.96	4.67	2.81	4.34	2.70	4.10	2.62	3.93	2.55	3.79	2.45	3.59	2.38	3.45	2.29	3.27	2.23	3.16	2.15	3.00	2.08	2.86	2.02	2.76	1.96	2.65	17
18	4.41	8.28	3.55	6.01	3.16	5.09	2.93	4.58	2.77	4.25	2.66	4.01	2.58	3.85	2.51	3.71	2.41	3.51	2.34	3.37	2.25	3.19	2.19	3.07	2.11	2.91	2.04	2.78	1.98	2.68	1.92	2.57	18
19	4.38	8.18	3.52	5.93	3.13	5.01	2.90	4.50	2.74	4.17	2.63	3.94	2.55	3.77	2.48	3.63	2.38	3.43	2.31	3.30	2.21	3.12	2.15	3.00	2.07	2.84	2.00	2.70	1.94	2.60	1.88	2.49	19
20	4.35	8.10	3.49	5.85	3.10	4.94	2.87	4.43	2.71	4.10	2.60	3.87	2.52	3.71	2.45	3.56	2.35	3.37	2.28	3.23	2.18	3.05	2.12	2.94	2.04	2.77	1.96	2.63	1.90	2.53	1.84	2.42	20
21	4.32	8.02	3.47	5.78	3.07	4.87	2.84	4.37	2.68	4.04	2.57	3.81	2.49	3.65	2.42	3.51	2.32	3.31	2.25	3.17	2.15	2.99	2.09	2.88	2.00	2.72	1.93	2.58	1.87	2.47	1.81	2.36	21
22	4.30	7.94	3.44	5.72	3.05	4.82	2.82	4.31	2.66	3.99	2.55	3.76	2.47	3.59	2.40	3.45	2.30	3.26	2.23	3.12	2.13	2.94	2.07	2.83	1.98	2.67	1.91	2.53	1.84	2.42	1.78	2.31	22
23	4.28	7.88	3.42	5.66	3.03	4.76	2.80	4.26	2.64	3.94	2.53	3.71	2.45	3.54	2.38	3.41	2.28	3.21	2.20	3.07	2.10	2.89	2.04	2.78	1.96	2.62	1.88	2.48	1.82	2.37	1.76	2.26	23
24	4.26	7.82	3.40	5.61	3.01	4.72	2.78	4.22	2.62	3.90	2.51	3.67	2.43	3.50	2.36	3.36	2.26	3.17	2.18	3.03	2.09	2.85	2.02	2.74	1.94	2.58	1.86	2.44	1.80	2.33	1.73	2.21	24
25	4.24	7.77	3.38	5.57	2.99	4.68	2.76	4.18	2.60	3.86	2.49	3.63	2.41	3.46	2.34	3.32	2.24	3.13	2.16	2.99	2.06	2.81	2.00	2.70	1.92	2.54	1.84	2.40	1.77	2.29	1.71	2.17	25
26	4.22	7.72	3.37	5.53	2.98	4.64	2.74	4.14	2.59	3.82	2.47	3.59	2.39	3.42	2.32	3.29	2.22	3.09	2.15	2.96	2.05	2.77	1.99	2.66	1.90	2.50	1.82	2.36	1.76	2.25	1.69	2.13	26
27	4.21	7.68	3.35	5.49	2.96	4.60	2.73	4.11	2.57	3.79	2.46	3.56	2.37	3.39	2.30	3.26	2.20	3.06	2.13	2.93	2.03	2.74	1.97	2.63	1.88	2.47	1.80	2.33	1.74	2.21	1.67	2.10	27
28	4.20	7.64	3.34	5.45	2.95	4.57	2.71	4.07	2.56	3.76	2.44	3.53	2.36	3.36	2.29	3.23	2.19	3.03	2.12	2.90	2.02	2.71	1.96	2.60	1.87	2.44	1.78	2.30	1.72	2.18	1.65	2.06	28
29	4.18	7.60	3.33	5.42	2.93	4.54	2.70	4.04	2.54	3.73	2.43	3.50	2.35	3.33	2.28	3.20	2.18	3.00	2.10	2.87	2.00	2.68	1.94	2.57	1.85	2.41	1.77	2.27	1.71	2.15	1.64	2.03	29
30	4.17	7.56	3.32	5.39	2.92	4.51	2.69	4.02	2.53	3.70	2.42	3.47	2.34	3.30	2.27	3.17	2.16	2.98	2.09	2.84	1.99	2.66	1.93	2.55	1.84	2.38	1.76	2.24	1.69	2.13	1.62	2.01	30
32	4.15	7.50	3.30	5.34	2.90	4.46	2.67	3.97	2.51	3.66	2.40	3.42	2.32	3.25	2.25	3.12	2.14	2.94	2.07	2.80	1.97	2.62	1.91	2.51	1.82	2.34	1.74	2.20	1.67	2.08	1.59	1.96	32
34	4.13	7.44	3.28	5.29	2.88	4.42	2.65	3.93	2.49	3.61	2.38	3.38	2.30	3.21	2.23	3.08	2.12	2.89	2.05	2.76	1.95	2.58	1.89	2.47	1.80	2.30	1.71	2.15	1.64	2.04	1.57	1.91	34
38	4.10	7.35	3.25	5.21	2.85	4.34	2.62	3.86	2.46	3.54	2.35	3.32	2.26	3.15	2.19	3.02	2.09	2.82	2.02	2.69	1.92	2.51	1.85	2.40	1.76	2.22	1.67	2.08	1.60	1.97	1.53	1.84	38
42	4.07	7.27	3.22	5.15	2.83	4.29	2.59	3.80	2.44	3.49	2.32	3.26	2.24	3.10	2.17	2.96	2.06	2.77	1.99	2.64	1.89	2.46	1.82	2.35	1.73	2.17	1.64	2.02	1.57	1.91	1.49	1.78	42
46	4.05	7.21	3.20	5.10	2.81	4.24	2.57	3.76	2.42	3.44	2.30	3.22	2.22	3.05	2.14	2.92	2.04	2.73	1.97	2.60	1.87	2.42	1.80	2.30	1.71	2.13	1.62	1.98	1.54	1.86	1.46	1.72	46
50	4.03	7.17	3.18	5.06	2.79	4.20	2.56	3.72	2.40	3.41	2.29	3.18	2.20	3.02	2.13	2.88	2.02	2.70	1.95	2.56	1.85	2.39	1.78	2.26	1.69	2.10	1.60	1.94	1.52	1.82	1.44	1.68	50
60	4.00	7.08	3.15	4.98	2.76	4.13	2.52	3.65	2.37	3.34	2.25	3.12	2.17	2.95	2.10	2.82	1.99	2.63	1.92	2.50	1.81	2.32	1.75	2.20	1.65	2.03	1.56	1.87	1.48	1.74	1.39	1.60	60
80	3.96	6.96	3.11	4.88	2.72	4.04	2.48	3.56	2.33	3.25	2.21	3.04	2.12	2.87	2.05	2.74	1.95	2.55	1.88	2.41	1.77	2.24	1.70	2.11	1.60	1.94	1.51	1.78	1.42	1.65	1.32	1.49	80
100	3.94	6.90	3.09	4.82	2.70	3.98	2.46	3.51	2.30	3.20	2.19	2.99	2.10	2.82	2.03	2.69	1.92	2.51	1.85	2.36	1.75	2.19	1.68	2.06	1.57	1.89	1.48	1.73	1.39	1.59	1.28	1.43	100
200	3.89	6.76	3.04	4.71	2.65	3.88	2.41	3.41	2.26	3.11	2.14	2.90	2.05	2.73	1.98	2.60	1.87	2.41	1.80	2.28	1.69	2.09	1.62	1.97	1.52	1.79	1.42	1.62	1.32	1.48	1.19	1.28	200
1,000	3.85	6.66	3.00	4.62	2.61	3.80	2.38	3.34	2.22	3.04	2.10	2.82	2.02	2.66	1.95	2.53	1.84	2.34	1.76	2.20	1.65	2.01	1.58	1.89	1.47	1.71	1.36	1.54	1.26	1.38	1.08	1.11	1,000
∞	3.84	6.64	2.99	4.60	2.60	3.78	2.37	3.32	2.21	3.02	2.09	2.80	2.01	2.64	1.94	2.51	1.83	2.32	1.75	2.18	1.64	1.99	1.57	1.87	1.46	1.69	1.35	1.52	1.24	1.36	1.00	1.00	∞

Reproduced from "Statistical Methods," by G. W. Snedecor, Collegiate Press, Iowa, 1937.

Table 8.

be tested by, first setting up the null hypothesis that they are from the same population. Then we would determine if the probability of the z function so calculated is comparable to what would exist if the 2 sigmas differed due to chance variations alone.

However, the z test has been largely supplanted by a more modern test, called the F test. (Note—both x and F tests actually require the use of the population for complete accuracy. However, sample sigmas may be used if N is not too small.)

F—Variance Ratio

The F variance ratio is:

$$F = \frac{\sigma_1^2}{\sigma_2^2} \qquad (33)$$

It is used in a manner similar to the z ratio and its functions are shown in Table 8. The F ratio is illustrated by the following example: In the white lead shipment previously referred to, tinting strength determinations from the 30 bag sample had a $\sigma = 8.0$. An additional 20 bag sample is taken from another car of the same shipment. This sample has a $\sigma = 5.5$. Do these samples have the same variability?

The variances are set up so that the subscript 1 is associated with the larger value. This has the effect of making F a positive number.

$$\sigma_1 = 8.0 \qquad \sigma_2 = 5.5$$
$$\sigma_1^2 = 64.00 \qquad \sigma_2^2 = 30.25$$
$$N_1 = 30 \qquad N_2 = 20$$
$$DF_1 = 29 \qquad DF_2 = 19$$
$$F = \frac{\sigma_1^2}{\sigma_2^2} = \frac{64.00}{30.25} = 2.12$$

Referring to Table 8,

for $DF_1 = 29$ and $DF_2 = 19$

for $p = 0.05$ $\quad F = 2.08$

$p = 0.01$ $\quad F = 2.86$

The value of F is very close to the 5% limit, indicating that even if the variances were equivalent, 1 time in 20 they could differ as shown by chance alone. If this amount of risk is too great—if perhaps it caused too high a percentage to violate a tinting strength specification—then sampling can be continued to determine, by further F testing, a more accurate estimate of the reliability of the dispersion of the test results.

Courtesy of International Business Machines Corp.

This card punch is said to combine efficiency, speed, and ease of operation. One of the features claimed is automatic card control of programming, a method of controlling skipping and duplicating which eliminates skip bars and tabular inserts.

INTERPRETATION and ANALYSIS

IN this section, we will discuss the use of the fundamental tools we have examined above in somewhat more elaborate, but extremely useful techniques of measurement, interpretation and analysis.

> *"The scientific method . . . consists in the careful and laborious classification of facts, in the comparison of their relationship and sequences, and finally the discovery by the aid of disciplined imagination of a brief statement or formula, which in a few words resumes a wide range of facts. Such a formula . . . is termed a scientific law."*
>
> **Karl Pearson**

Relations - Correlations - Fitting

Testing Fit to a Normal Curve

In the previous discussion of the data of gloss readings of 113 white paints, a normal distribution curve was fitted to the data in Figure 4. Examination of theoretical normal curve areas indicated that the frequency distribution curve of Figure 1 was not normal.

A chi square test (21) can be run to actually test the goodness of fit of the normal curve drawn to the observed data. The particular equation for χ^2 used is:

$$\chi^2 = \Sigma \left(\frac{f - f_c}{f_c} \right)^2 \qquad (34)$$

where f is an observed frequency in a class and f_3 is the corresponding theoretical frequency or expected value. Table 9 shows the computation of χ^2 for the data involved.

Because of the great effect on χ^2 of differences between small observed and expected frequencies at the end of a distribution, it is generally necessary to combine 2 or more classes at each end. Fisher suggests that no group should contain fewer 5 expected frequencies. This has been done in Table 9, leaving 8 classes.

The number of degrees of freedom remaining for error for this case is obtained by subtracting from the number of classes, the number of

Gloss Readings						
Class	Mid-point	f observed	f_c expected	$f\text{-}f_c$	$(f\text{-}f_c)^2$	$\frac{(f\text{-}f_c)^2}{f_c}$
1-5	3	3	3.0	4.0	16.00	1.60
6-10	8	11	7.0			
11-15	13	13	12.7	0.3	0.09	0.01
16-20	18	22	18.8	3.2	10.24	0.55
21-25	23	19	21.6	−2.6	6.76	0.31
26-30	28	14	20.0	−6.0	36.00	1.80
31-35	33	13	14.3	−1.3	1.69	0.12
36-40	38	11	8.4	2.6	6.76	0.81
41-45	43	4	4.0	1.6	2.56	0.47
46-50	48	3	1.4			
Total		113	111.2			5.67

$X^2 = 5.67$ D.F. $= 8 - 3 = 5$
for $p = 0.50$ $X^2 = 4.351$
for $p = 0.30$ $X^2 = 6.064$
Therefore, $p \cong 0.40$ of $X^2 = 5.67$

Table 9. Chi square test for goodness of fit for normal curve fitted to data of gloss readings of 113 white paints.

degrees of freedom lost in the fitting process. Here 3 degrees of freedom were lost because the original data and the fitted data were made to agree with respect to N, $\overline{X}$ and σ (Figure 4). Therefore DF = 8 − 3 = 5.

From Table 9, $\chi^2 = 5.67$ and $p = 0.40$. This indicates that contrary to what we have suspected, the normal curve is a good description of the data, since, if the distribution of glosses is actually normal, we might expect a fit as bad or worse than this about 40 times out of 100, because of chance variations attributable to sampling and testing. This probability is considerably higher than the 5% level.

Tests on Differences of Data—Pairing.

Suppose we are interested in comparing the corrosion resistance of steel pipe coated with a red lead primer against that of steel pipe cathodically protected. We also want to know how the corrosion will be affected by the type of soil in which the pipe is buried. (23)

Pairing of the samples of the 2 protected pipes in the various soils used is a simple technique which accomplishes the following:

(1) *Practicality*—it makes possible the introduction into the experiment of variability in such important factors as type of soil and period of burial, thus making the experiment feasible in a practical manner and allowing it to simulate conditions of industrial life.

(2) *Precision*—it excludes the influence of the variability of these factors on the precision of inferences relating the arithmetic means.

The data of this experiment is shown in Table 10, together with the calculations referred to below. The effect, corrosion, is measured as depth of maximum pits (in 0.001 inches). Each of the quantities, d, is unaffected by differences among various soils, the various lengths of burial, and the variable weather during burial, for in each pairing both kinds of pipe are treated alike with respect to these factors. Hence the error of $\overline{d}$ tends to be small. At the same time the experiment manages to include the various soils and burial conditions commonly encountered in the industrial use of these coatings and treatments.

Controls		Depth of Maximum Pits (0.001 in.)		
Kind of Soil	Years Buried	Red Lead X_R	Cathodic X_c	$d = X_r - X_3$ Difference
Clay	4.5	73	51	+22
Clay	3.8	43	41	+22
Cinders	7.1	47	43	+ 4
Cinders	6.1	53	41	+12
Peat	2.0	58	47	+11
Tidal Marsh	4.4	47	32	+15
Loam	5.5	52	24	+28
Clay	9.2	38	43	− 5
Clay	8.5	61	53	+ 8
Clay	8.0	56	52	+ 4
Loam	5.7	56	57	− 1
Clay	3.2	34	44	−10
Clay	4.2	55	57	− 2
Loam	6.6	65	40	+25
Alkali Knoll	6.4	75	68	+ 7
Totals	N = 15	813	693	+120

$\overline{X}$	54.2	46.2	
$\overline{d}$			+8.0
$\sigma_{\overline{X}R\text{-}\overline{X}C} = 4.08$			
		$\sigma_{\overline{d}} = 2.847$	

Table 10. Corrosion tests of protected steel pipe.

Referring to Table 10, the standard deviation of the difference of the means of the 2 sets of data is shown as $\sigma_{\overline{X}R\text{-}\overline{X}C} = 4.08$. (Calculations are not shown but they are standard. A t test on this data gives (Null Hypothesis—both sets

$$t = \frac{(\overline{X}_R - \overline{X}_c) - 0}{\sigma_{\overline{X}_R - \overline{X}_c}} = \frac{54.2 - 46.2}{4.08} = \frac{8.0}{4.08} = 1.96$$

of data from the same population, $\overline{X}_R - \overline{X}_c = 0$).

Since all the data was used, and 2 means were calculated, DF = 30 − 2 = 28. Referring to Figure 6, p = 0.03 (one side) or p = 0.06 (both sides). Therefore since p is just above the 5% level, we would say that this method indicates that there is no significant difference in corrosion between the pipe treatments.

However, checking the increased significance of the t test on the paired differences, for an expected value of $d' = 0$, and with $\sigma_{\overline{d}} = 2.847$:

$$t = \frac{\overline{d} - \overline{d}'}{\sigma_{\overline{d}}} = \frac{8.0 - 0}{2.847} = 2.81$$

Here we have DF = 15 − 1 = 14 and, referring to Figure 6, p = 0.008

(one side) or p = 0.016 (both sides). This figure is below our 5% level but above the 1% level. The probability obtained casts considerable doubt upon the veracity of the Null Hypothesis although not completely disproving it. However, this result is more significant than the previous estimate because of the increased *power* of the test on differences, which are correlated.

It is interesting to note that our estimates of $\bar{d}$ from paired differences are better than those from unpaired data—even though in pairing we have lost precision due to a 50% reduction in the number of items compared.

Pairing techniques are discussed in great detail by Youden (5), particularly with reference to block design of experiments.

Randomization

In the foregoing experiment, a third objective would be to avoid *bias*, or any discrimination (intentional or otherwise) between test situations. This may be accomplished by ***randomization.***

When certain influential test factors cannot be controlled, or it is not feasible or economical to control them, their effects cannot be eliminated but they can be distributed so that the desired comparisons of means and differences are not vitiated by their presence.

Randomization provides a completely objective technique of removing the possible systematic effects of uncontrolled factors. Two common methods of randomization—particularly as regards sampling from parent populations—are:

(1) choosing samples in the order given by tables of random numbers. (26).

(2) drawing numbers at random from a bowl of marked chips or slips.

In short, randomization will insure the fact that each and every member of a population will have an equal probability of being chosen in a sample.

Sometimes physical location of desired items makes randomization difficult—for example, location of bags in a warehouse or drums on a skid. These situations necessitate compromises but every effort should be made to remove subjective decision and its attendant biases from the method of selection.

Touchin (53) has said that randomization is essential in all work based on statistical method, for without randomization, any statistical analysis was invalid.

Analysis of Variance

We will now extend our discussion of the variability of means and consider the significance of differences among several means.

Suppose we are interested in measuring the effect on alkyd viscosity of 4 different lots of pentaerythritol used in a standard alkyd formula processed under standard conditions. The experiment has already been run in the conventional manner making 5 resins with each lot of pentaerythritol—until a total of 20 resins has been made. The results, expressed as alkyd viscosity in poises (with a Gardner range of Z2-Z4) are tabulated in Table 11. (Data from [15].)

We realize that even if the 4 lots of pentaerythritol are the same, the 4 column means are not likely to be identical. For, if from 4 populations of pentaerythritol (which we shall assume to be normal) which are alike in their means as well as in their variances, 4 random samples each of 5 observations are drawn, the 4 samples means will differ among themselves by chance (23). Our problem is to determine whether or not the observed variation in column means can be so explained. If it cannot, the hypothesis that the 4 normal populations are alike in their means and variances is rejected. Then, it will be concluded that the means of the 4 populations differ significantly among themselves, i.e., the 4 lots of pentaerythritol differ significantly, in a statistical sense, in their effects on alkyd viscosity.

If the 4 lots are alike in their effect on viscosity, the column means will vary about their mean by an amount which can be determined from the variation of the individual observations in the columns about their respective column means. For, if the only identifiable factor (differences among lots) is without effect, both variations among column means and within columns are allocable to the same host of unidentifiable factors. Notice that it is not stated that, if lots are alike in their effects, the variation among

FINAL ALKYD VISCOSITY — POISES

Repeat Tests	Lots of Pentaerythritol								
	A	Sq.	B	Sq.	C	Sq.	D	Sq.	Grand Totals
1-4	80	6400	33	1089	65	4225	50	2500	
5-8	78	6084	45	2025	65	4225	60	3600	
9-12	80	6400	33	1089	64	4096	46	2116	
13-16	85	7225	36	1296	70	4900	59	3481	
17-20	78	6084	40	1600	63	3969	55	3025	
ΣX_{col}	401		187		327		270		1185
$\bar{X}_c$	80.2		37.4		65.4		54.0		59.25
$(\Sigma X_c)^2$	160801		34969		106929		72900		375,599
ΣX_c^2		32193		7099		21415		14722	75,429

Table 11. Alkyd tests analysis of variance.

column means will be *equal* to that within columns, because, although both variations are caused by the same forces, averages will always vary less than the individual observations of which they are formed.

If differences among lots really affect viscosity, the variation within columns will still arise from chance, unidentifiable causes. However, the variation among column means is now attributable to these factors *and* to real differences among lots.

We can accomplish this comparison by an *Analysis of Variance*—determining the variance among columns and within columns and testing their ratio for significance with an F test. If we represent the result of each test as X, the results within columns as X_c, column means as $\overline{X}_c$, and the average of all the results—the grand average—as $\overline{\overline{X}}$, N as the total number of test results and n_c as the number of columns, then the equations for variance become:

TOTAL VARIANCE

$$\sigma^2 = \frac{\Sigma(X-\overline{\overline{X}})^2}{N-1} = \frac{\Sigma X^2 - \frac{(\Sigma X)^2}{N}}{N-1} \qquad (35)$$

VARIANCE BETWEEN COLUMNS

$$\sigma^2 = \frac{\Sigma n_c(\overline{X}_c-\overline{\overline{X}})^2}{n_c-1} = \frac{\frac{n_c}{N}\Sigma(\Sigma X_c)^2 - \frac{(\Sigma X)^2}{N}}{n_c-1} \qquad (36)$$

VARIANCE WITHIN COLUMNS

$$\sigma^2 = \frac{\Sigma[\Sigma(X_c-\overline{X}_c)^2]}{N-n_c} = \frac{\Sigma[\Sigma X_c^2 - \frac{N(\Sigma X_c)^2}{n_c}]}{N-n_c} \qquad (37)$$

Computations here can be simplified because the numerators of the above equations—commonly called the *"sum of squares"* are additive and may be computed from the total sum of squares by difference. Likewise, degrees of freedom (in the denominator) are additive. The variance is not additive and must be computed from its respective sum of squares and degrees of freedom.

Referring to Table 11, the sum of squares are calculated thus:

$$\frac{(\Sigma X)^2}{N} = \frac{(1185)^2}{20} = 70{,}211$$

$$\Sigma X^2 = 75{,}429$$

$$\frac{n_c}{N}\Sigma(\Sigma X_c)^2 = \frac{375{,}599}{5} = 75{,}120$$

Source of Variance	Sum of Squares	Degrees of Freedom	Variance
Total	5218	20-1 = 19	275
Between Columns	4909	4-1 = 3	1636
Within Columns	309	20-4 = 16	19.3

Table 12

Sum of Squares—

Total = 75,429-70,211 = 5218

Between = 75,120-70,211 = 4909

Within = 5,218- 4,909 = 309

These figures are entered into the formal table of Analysis of Variance (see Table 12).

The within columns variance is an estimate of the experimental error in this situation. Therefore the F test is made as follows:

$$F = \frac{1636}{19.3} = 84.8 \qquad DF_1 = 3 \quad DF_2 = 16$$

This value, when referred to Table 8, is found to be much higher than that which could occur frequently from chance alone. (p = 0.01, F = 5.29) Therefore the differences among lots of pentaerythritol are extremely significant.

Latin Squares

Were we given the opportunity to have planned the foregoing experiment, we would have no doubt attempted to gain much more information on the variables involved with the same number of experiments by a simple technique, called the *Latin Square.* ("Latin"—because Latin letters are usually used to identify the tests.) One such experiment is described below. (47)

This experiment was planned to study the effects of certain factors in the wrinkling of an enamel, the vehicle of which consisted of a mixture of an alkyd resin and an oleoresinous varnish. The factors studied were: various proportions of alkyd to oleoresinous varnish, varying amounts of an anti-skinning agent, and the effect of different drier combinations.

The different amounts of alkyd were represented by columns, the anti-skinning agent by rows and the drier mixtures by letters (see Table 13).

Inspection shows that every row and every column contains a complete set of treatments, and hence any difference between the means of each row and each column must be attributable to some factor other than the drier mixtures. This enables control to be established in 2 directions and hence, by making the rows represent variations in one factor, and the column another, it is possible to estimate the effect these 2 factors have on the treatments. Moreover, the effects of any given treatment are measured with great accuracy, since each row is in effect a complete replication of the treatments.

In this example, the 4 columns represent different proportions of alkyd and the accuracy of estimation of drier treatment "A" is precisely the same as though all the experiments with treatment "A" had been devoted to one proportion of alkyd; that is to say, the experiment is yielding information on 2 other factors (rows and columns)

		Alkyd			
	%	0	25	50	75
Anti-Skinning Agent	0	A	B	C	D
	0.5	B	D	A	C
	1	C	A	D	B
	2	D	C	B	A

Table 13

without any loss in the estimation of treatments A, B, C, D.

If the experiment had been carried out on orthodox lines, it would be necessary, for example, to test treatment "A" 4 times with each proportion of alkyd and 4 times with each % of anti-skinning agent in order to arrive at an estimation of "A" with the same precision as is given by the Latin Square and—at the same time—obtain the same information on the effect of alkyd and the effect of anti-skinning agent.

In the experiment, 3 mil films were drawn down on glass plates with an applicator. The plates were placed in a constant temperature cabinet at 65°F. for 7 days and examined for wrinkling, which was estimated visually, with 10 representing a completely wrinkle-free panel, and 0 a completely wrinkled film. Table 14 shows the estimates so obtained plus many of the calculations required for the analysis of variance.

The total sum of squares is calculated using Equation (35). Since the Latin Squares is symmetrical, i.e., the number of rows, columns, and letters are the same, the equation for the sum of squares for each treatment is as follows: (where n_c is the side of the square)

$$\text{SUM OF SQUARES}_{(\text{Treatments})} = \frac{\Sigma(\Sigma X_c)^2}{n_c} - \frac{(\Sigma X)^2}{N} \qquad (38)$$

Table 15 gives the analysis of variance.

The residual (error) sum of squares has been calculated by difference from the total. Also, since there are 16 experiments, there are 15 total degrees of freedom, 3 degrees of freedom for each source of variance; therefore the residual degrees of freedom are equal to $15-(3+3+3)=6$.

Next, each of the treatment variances is compared to the residual variance in an F test (3 and 6 degrees of freedom) with these results:

$$F \text{ (anti-skin—rows)} = \frac{1}{1.3} = 0.77$$

$$F \text{ (Alkyd—columns)} = \frac{0.67}{1.3} = 0.5$$

$$F \text{ (driers—letters)} = \frac{46.3}{1.3} = 35.6$$

For $DF_1=3$ and $DF_2=6$, Table 8 shows that $F=4.8$ at the 5% level and $F=9.8$ at the 1% level.

From the results, it is apparent that the only significant factor was the drier combination. Having established this vital fact, the differences between each drier combination can be tested for significance by Students' t tests applied to the means. Here, the test sigma is the sigma for the residual error, divided by n_c. Table 6 shows $t=2.447$ for DF=6 at the 95% probability level (both sides). Therefore, if $\Delta\bar{X}$ is the difference between means that is significant at the 95% level

$$t = \frac{\Delta\bar{X}}{\frac{\sqrt{1.3}}{\sqrt{4}}} = 2.447 =$$

$$\frac{\Delta\bar{X}}{\sqrt{0.325}} = \frac{\Delta\bar{X}}{0.570} \qquad \Delta\bar{X} = 1.39$$

The difference between means is 1.39. The observed means are (Table 14): A—2.25, B—8.75, C—8.75, D—9.50.

Therefore, combinations B, C and D are significantly different from A. In fact, the B, C and D combinations contained an ingredient not present in A, increasing in amount through B, C and D. Since certain technical reasons prohibit the use in practice of the quantities present in C and D, the combination B was adopted.

The experiment thus indicated that the anti-skinning agent had no effect at all in preventing skinning and that having chosen a suitable drier combination the relative amounts of alkyd resin and oleoresinous varnish could be varied

%		ALKYD 0 X	X^2	25 X	X^2	50 X	X^2	75 X	X^2	ΣX_R	$(\Sigma X_R)^2$	ΣX^2	
ANTI-SKINNING AGENT	0	4	A 16	8	B 64	9	C 81	9	D 81	30	900	242	$\Sigma X_A = 9$, $(\Sigma X_A)^2 = 81$
	0.5	9	B 81	10	D 100	1	A 1	7	C 49	27	729	231	$\Sigma X_B = 35$, $(\Sigma X_B)^2 = 1225$
	1	9	C 81	1	A 1	10	D 100	9	B 81	29	841	263	$\Sigma X_C = 35$, $(\Sigma X_C)^2 = 1225$
	2	9	D 81	10	C 100	9	B 81	3	A 9	31	961	271	$\Sigma X_D = 38$, $(\Sigma X_D)^2 = 1444$
ΣX_c		31		29		29		28		117	3431	1007	3975
$(\Sigma X_c)^2$		961		841		841		784					

$$\left[(\Sigma X_c)^2\right] = 3427 \qquad \frac{(\Sigma X)^2}{N} = \frac{(117)^2}{16} = 855.56$$

SUM OF SQUARES (COLUMNS)

$$= \frac{3427}{4} - 855.56 = 856.75 - 855.56 = 1.21 \text{ OR } 2$$

$$SS_{(Rows)} = \frac{3431}{4} - 855.56 = 857.75 - 855.56 = 2.21 \text{ OR } 3$$

$$SS_{(Letters)} = \frac{3975}{4} - 855.56 = 993.75 - 855.56 = 138.19 \text{ OR } 139$$

$$SS_{(Total)} = 1007 - 855.56 = 151.44 \text{ OR } 152$$

Table 14. Wrinkling tests—Latin Square.

Source of Variance	Sum of Squares	Degrees of Freedom	Variance
Anti-skinning agent (rows)	3	3	1
Alkyd (columns)	2	3	0.67
Driers (letters)	139	3	46.3
Residual	8	6	1.3
Total	152	15	

Table 15

within any limits imposed by other technical considerations without affecting the tendency of the paint to skin.

It will be apparent that a great deal of precise and useful information has been attained for a relatively small amount of experimental work and the application of this type of design to other problems will readily suggest itself. Squares of sides 3, 5, and 6 can be used in a similar manner. Squares larger than this become a little unwieldy and it is better in examining a large number of factors to break the experiments up into a number of small squares.

This design is very suitable for studying factory problems where the variations between machines or between different methods of charging may have to be taken into account as a possible variable affecting the product, allowing the experimenter to work with a number of machines at the same time and with less disruption of the normal production processes.

Factorial Experimentation

When experimenting with a number of independent variables, the classical method of experimentation is to hold all the variable factors constant except one (47). This procedure possesses notable disadvantages in that in varying one factor the others should be allowed to vary over their full range in order to obtain a reasonable assessment of the effects. However, by holding the various factors constant, they remain so at some completely arbitrary level. The factorial design has been devised to cope with this situation, namely the interaction of factors, and has also helped to solve the interpretation of the large number of results that are inevitably obtained in an experiment where a number of factors are varied. This approach is somewhat different from the classical method:

(1) Emphasis is laid on obtaining an accurate estimate of the size of the error rather than to minimize it, thus enabling an exact test of significance to be applied.

(2) The same standard of accuracy can be obtained with a smaller number of observations, giving greater economy of effort.

(3) Information is obtained on the interaction of factors.

A few words on the subject of interaction would be in order at this point. Suppose we are measuring the reaction rate of a monomer in a latex processing kettle, with an initial catalyst concentration C_1 and a temperature of reaction, T_1. Assume that if we double C_1, the rate is increased by an amount R_1. At the original catalyst concentration C_1, if we double T_1, we may expect an increase in reaction rate of R_2. If we double both C_1 and T_1—and the rate increases by an amount R_1+R_2—we say there is no *interaction*. However, if as is actually the case, the rate change has no relationship to R_1+R_2, we say that there is an interaction between the 2 variables C and T in producing effect R. Grinsfelder has shown several examples of interaction in tabular and graphical form (11).

Alkyd sample being taken from pilot cook for viscosity determination during a regression analysis.

In the "complete factorial" used' the experiment is so designed that each level of each factor is combined with each level of every other factor. By so doing, both the independent effects of each variable may be studied as well as the interactions of one variable on another.

The complete factorial is readily used when either 2 or 3 factors are deemed worthy of study. When 4 factors are to be studied, the complete factorial can be used but the mathematical calculation become rather involved. For 4 factors at each of 2 levels, a total of 2^4 or 16 experimental runs are required. For 4 factors at each of 3 levels, 3^4 or 81 experimental runs are needed. It is readily seen that more than the mathematical treatment becomes involved as the complete factorial is applied to larger than 3 factors.

In addition, it is often useless to learn about third order or higher degree interactions, for even if they exist, there is generally very little an experimenter can do to understand or control such events. The general recourse in this situation is to use the higher order reaction terms as the error terms in the analysis of variance.

The advantages of the factorial design can be built into a multivariate investigation by using what is known as the partial factorial or "fractional replicate". An example is shown below:

	A_1		A_2	
	B_1	B_2	B_1	B_2
C_1	X_4			X_1
C_2		X_3	X_2	

By proper analysis of such a set of experiments, it is possible to determine the effect of factor A by comparing the average of the 2 left hand sets with the 2 right hand sets. The effect of factor B is estimated by the difference between the average of runs 1 and 3, and the average of runs 2 and 4. Factor C of course will derive from averages of 1 and 4 and 2 and 3.

Interaction effects can also be established. The effect of A at level 1 of B is estimated by the difference between the results of runs 2 and 4. The effect of A at level 2 of B is estimated by the difference between runs 1 and 3. If these 2 effects are not the same, then A and B interact.

For illustrative purposes, a complete 5 factor factorial experiment will now be described. It is rather complex, but it shows to full advantage the extensive and powerful probe this technique affords. It involved a problem in formulation and was analyzed by Saunders (47).

Preliminary laboratory tests had shown that a new type of plasticizer

for urea-formaldehyde resins possessed useful properties, but the system seemed sensitive to baking temperatures and the addition of small amounts of an organic acid catalyst. It also appeared that the quantity of plasticizing resin was critical and that the addition of rosin showed some improvements. The factorial experiment set up and the factors and their levels are shown in Table 16.

Factors (Symbols)		Levels	No. of Levels
Baking Time,	T	T_1 T_2	2
Baking Temperature,	t	t_1 t_2	2
Plast.—U/F ratio,	P	$P_1(1/2)$, $P_2(1/1)$, $P_3(2/1)$	3
Rosin,	R	R_1 (0%), R_2 (5%)	2
Organic acid,	A	A_1 (0.15%), A_2 (0.75%)	2

Table 16

The total number of experiments is, therefore 2 x 2 x 3 x 2 x 2 = 48, and the total number of mixtures is 3 x 2 x 2 = 12. The 12 blends were prepared and applied by spraying to 48 tin plate panels to give a dry film weight of ¾—1 oz. per sq. yd. The panels were baked in 2 batches of 24 each in a gas-convection oven controlled to within 5°F. At each temperature 12 panels were withdrawn after time t_1 and remainder after time t_2. Six hours after removal from the oven scratch hardness readings were run in triplicate on each panel. The results are shown in Table 17, each figure being the mean of the 3 determinations. (The figures have also had 900 subtracted from them and are divided by 100 to reduce the arithmetic.)

The analysis of variance is shown in Table 18. In this example, the residual variance against which the treatment variances are tested is the 5 factor interaction, time x temperature x U/F—Plasticizer ratio x rosin x acid (TtRAP) which is assumed to be negligibly small compared to the main effects or the other interactions. The sum of squares are calculated as indicated above in the fractional replicate discussion. For example, the sum of squares for T is computed by summing the entries in the left hand section of Table 18 under T_1 and subtracting these from the sum of values for the higher level, T_2. This difference is then squared and divided by N = 48. Thus $\Sigma T_2 = 112$; $\Sigma T_1 = 90$. $\Sigma T_2 - \Sigma T_1 = 112 - 90 = 22$.

$$\text{Sum of Squares (T)} = \frac{(22)^2}{48} = 10.83$$

The sum of squares for the other main effects are obtained in a similar manner. The sum of squares for the 2-factor interaction Tt is obtained as follows: The sum of the values having the lower levels of T and t in common is added to the sum of values having the higher levels, T_2 and t_2, in common. This total sum is subtracted from the sum of the remaining values. This difference is squared and divided by 48, yielding the desired interaction mean square. Thus, for interaction

$$Tt \Sigma T_1 t_1 + \Sigma T_2 t_2 = 104;$$
$$\text{Remainder} = 98.$$
$$\text{Diff.} = 104 - 98 = 6.$$
$$\text{Sum of Squares (interaction Tt)} = \frac{(6)^2}{48} = \frac{36}{48} = 0.750$$

The other interactions and the higher order interactions are obtained in a similar fashion by summing and differencing. The Yates (8) method of computing the mean squares can also be used here, but it works best if the factors are present only at 2 levels.

It should be noted here that all the main effects and interactions where the variables are present at 2 levels have one degree of freedom. However, the effect, P, and all associated interactions have 2 degrees of freedom, because P is present in 3 levels.

Certain precautions are necessary in applying the F test. The residual is compared against the smallest interaction term, and if that term is not significant it is pooled with the residual to give a new residual against which the other interactions in ascending order of magnitude are tested.

Applying this process none of the 4-factor interactions are, and only one of the 3-factor interactions, TtR, is significant. Since the 2-Factor terms Tt, tR, TR are involved, these 3 terms are pooled with the TtR term (together with their degrees of freedom for more precision) to give a fresh estimate. Pooling all of the insignificant 3- and 4-factor interactions with the residual, Table 18 is adjusted and Table 19 results.

From Table 19, it is clear that there is a significant TP, and possibly AP interaction. The next step therefore is to break the data down into two 4-factor experiments and

		T_1				T_2				
		t_1		t_2		t_1		t_2		
		R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2	ΣX
A_1	P_1	1	0	2	1	6	3	6	6	25
	P_2	4	5	5	4	6	3	6	5	38
	P_3	4	4	5	5	4	4	4	3	33
A_2	P_1	2	2	3	2	5	4	7	6	31
	P_2	5	5	7	5	5	5	6	7	45
	P_3	5	5	5	4	4	1	3	3	30
ΣX		21	21	27	21	30	20	32	30	

Table 17. Hardness Tests—Factorial Design.

Source of Variance	Sum of Squares	D.F.	Variance
T	10.083	1	10.083
t	6.750	1	6.750
R	6.750	1	6.750
A	2.083	1	2.083
P	24.542	2	12.271
Tt	0.750	1	0.750
TR	0.750	1	0.750
TA	2.084	1	2.084
TP	54.292	2	27.146
tR	0.083	1	0.083
tA	0.084	1	0.084
tP	2.625	2	1.313
RA	0.084	1	0.084
RP	0.375	2	0.187
AP	3.792	2	1.896
TtR	4.084	1	4.084
TtA	0.749	1	0.749
TtP	0.875	2	0.437
TRA	0.749	1	0.749
TRP	0.125	2	0.062
TAP	0.541	2	0.270
tRA	0.083	1	0.083
tRP	0.292	2	0.146
tAP	0.541	2	0.270
RAP	1.291	2	0.645
tTRA	0.084	1	0.084
tTRP	0.541	2	0.276
tTAP	1.126	2	0.563
tRAP	2.376	2	1.188
TRAP	1.542	2	0.771
Residual (tTRAP)	1.791	2	0.895
Total	131.917	47	

Table 18. Factorial—Analysis of Variance—I.

the obvious choice is according to temperature. In Table 20, this has been done and the main conclusions are as follows:

(1) At temperature t_1 it is important to choose the correct ratio of U/F resin—plasticizer and the amount of organic acid.

(2) at t_2 only the U/F—plasticizer ratio is important and even this is not completely critical.

(3) the effect of rosin is not significant

(4) the baking time is not critical

By application of the Student's t test, the means of the readings in the original table (Table 17) may be tested for significance and exact information obtained as to the precise effect of any factor affecting the scratch hardness. This allows the experimenter to choose any combination of the factors studied in accordance with his requirements, in the full knowledge that all the effects and interactions have been thoroughly explored within the levels at which each factor was varied.

Regression—Relation Between Variables—Correlation

Correlation may be thought of as involving three types of measurements, which may conveniently be made in the following order: (21)

(1) An *estimating* or *regression* equation which describes the functional relationship between 2 variables. As the name indicates, one object of such an equation is to make estimates of one variable from another. Thus, the equation $Y=a+bX$ is a statement of the regression of Y on X.

(2) A measure of the amount of variation of the actual values of the dependent variable (Y) from their estimated or computed values. This measure of the variation which has not been explained by the estimating equation is analogous to a standard deviation and gives an idea, in absolute terms, of the dependability of estimates. It is called the scatter, or standard error of estimate (σ_{ys}).

(3) A measure of the *degree* of relationship, or *correlation* (r), between the variables, independent of the units or terms in which they were originally expressed. A closely related measure, the coefficient of *determination*, r^2, will permit us to state the *relative* amount of variation which has been explained by the estimating equation.

The following example will examine the correlation between the nature of the oil modification of an alkyd resin and the resultant alkyd

Source of Variance	Sum of Squares	D.F.	Variance
T	10.083	1	10.083
t	6.750	1	6.750
R	6.750	1	6.750
A	2.083	1	2.083
P	24.542	2	12.271
TA	2.084	1	2.084
TP	54.292	2	27.146
tA	0.084	1	0.084
tP	2.625	2	1.312
RA	0.084	1	0.084
RP	0.375	2	0.187
AP	3.792	2	1.896
TtR	5.667	4	1.417
Residual	12.706	26	0.489
Total	131.917	47	

Table 19. Factorial—Analysis of Variance—II.

viscosity. An experiment was run in which 7 variations of a long oil phthalic alkyd were prepared, with the oil portion composed of mixtures of linseed and safflower oils. The ratio of linseed to safflower varied from 0 to 10 all the way to 6 to 4 in 7 steps. Four resins were made at each ratio—giving a total of 28 tests.

The data was collected as viscosities in poises (resins were Z1-Z3 at 70% N.V.) and is shown in Table 21, which also includes the requisite calculations for an analysis of variance. H_o, the appropriate null hypothesis, states that all of the viscosity means, Y_c, are from the same population; X, the oil ratio, has no effect and the differences between the $\overline{Y}_c$'s are due to chance. Table 22 is the variance table.

An F test showed, for $DF_1 = 6$ and $DF_2 = 21$

$$F = \frac{168.8}{2.8} = 60.3$$

for this value p is considerably less than 0.01. Therefore, the differences are extremely significant, the null hypothesis is disproven, and we have indicated that there is some causal relationship X and Y.

Figure 7 is a plot of the mean alkyd viscosities, $\overline{Y}_c$ versus the oil ratio, X. It appears that there may be a straight line relationship between the variables. We shall attempt to fit a straight line to the data, using the *method of least squares*.

Source Of Variance	VARIANCES	
	Experiment at t_1	Experiment at t_2
T	1.50	6.0
A	4.17	0
R	1.50	6.0
P	27.40	12.0
TR	1.50	2.67
TA	0.166	0.66
TP	0.125	1.67
RA	0.166	0.67
RP	0.125	0.17
AP	0.542	1.67
RTA	0.167	0
RTP	0.375	0
TAP	0.792	0
RAP	0.292	1.5
Residual	0.042	1.67

Table 20. Factorial—Analysis of Variance—III.

The theory of least squares states that:

(1) the sum of the vertical deviations of the data from the fitted line must equal zero.

(2) the sum of the squares of all these deviations, both above and below the line, must be a minimum—that is, less than the sum of squares of the deviations of the data from any other conceivable straight line.

The equation of the fitted line is:

$$Y_F = a + bX \quad (39)$$

where Y_F is the theoretical, fitted value of the viscosity

a = the intercept on the Y axis; the value of Y_F when X = O.

b = the slope of the line; the value of the change in Y_F for a unit change in X.

To determine the coefficients a and b in equation (39) the following *normal equations* are used:

$$\Sigma Y = Na + b\Sigma X \quad (40)$$

$$\Sigma XY = a\Sigma X + b\Sigma X^2 \quad (41)$$

Table 23 shows a tabulation of the viscosity means calculated in Table 22. In addition, the quantities X^2, Y^2, XY and their respective summations have been calculated. These were then substituted in equations (40, 41); the equations solved simultaneously and the coefficients a and b determined. The resulting equation for

	X→Linseed/Safflower Oil Ratio														TOTAL
	0		1		2		3		4		5		6		
	Y	Y^2	Y	Y^2	Y	Y^2	Y	Y^2	Y	Y^2	Y	Y^2	Y	Y^2	
	29	841	27	729	32	1024	29	841	38	1444	38	1444	48	2304	
Y = Viscosity Poises	26	676	30	900	28	784	30	900	37	1369	40	1600	44	1936	N = 28
	28	784	29	841	30	900	32	1024	36	1296	39	1521	42	1764	
	24	576	29	841	31	961	31	961	35	1225	39	1521	45	2025	$\overline{\overline{Y}} = 33.79$
ΣY	107		115		121		122		146		156		179		946
ΣY^2		2877		3311		3669		3726		5334		6086		8029	33032
$\overline{Y}$	26.75		28.75		30.25		30.50		36.50		39.0		44.75		236.50

Table 21. Alkyd viscosity vs. oil ratio.

the straight line relating actual oil ratio, X, with fitted viscosity, Y_F, is:

$$Y_F = 25.15 + 2.88X$$

The linear regression equation has been plotted on Figure 7, where the nature of the fit can be examined.

We then proceed to test the goodness of the fit with an analysis of variance. Here we are interested in determining if the deviations of our data from the regression line could be as large as they are due to chance alone.

The sum of squares corresponding to the variation unexplained by regression is then calculated as follows:

$$\Sigma_{nc} \left(\bar{Y} - \bar{Y}_F\right)^2 = n_c \left[\Sigma\bar{Y}^2 - \left(a\Sigma\bar{Y} + b\Sigma X\bar{Y}\right)\right]$$

This works out to a value of 80.20. ($n_c = 4$, the number in the column for the calculation of $\bar{Y}$, since we had grouped, replicated data). The degrees of freedom are 5, since we had 7 viscosity means and 2 calculated constants, a and b. The analysis of variance is given in Table 24.

Our null hypothesis is that the variation not explained is due to chance and is therefore not significantly different from the original within column variations. Our F test is then, for $DF_1 = 5$ and $DF_2 = 21$.

$$F = \frac{16}{2.8} = 5.71$$

for $p = 0.01$, F (from Table 8) $= 4.04$

The difference is significant and the hypothesis is disproven. The linear regression, while visually good, is not significant, since the variation left unexplained is significantly greater than that due to chance.

At this point, before leaving the linear regression, we will calculate the standard error of estimate and the correlation coefficients.

The standard error of estimate, σy_s, for the means is given by

$$\sigma_s = \sqrt{\frac{\Sigma(\bar{Y} - \bar{Y}_F)^2}{N}} = \sqrt{\frac{\Sigma\bar{Y}^2 - (a\Sigma\bar{Y} + b\Sigma X\bar{Y})}{N}} \quad (42)$$

For the 7 viscosity means in this test, $\sigma_{ys} = 1.70$. The significance of is analogous to the more common σ, in that lines drawn parallel to the regression line, but at distances measured along the Y axis of $\pm 1, 2$ and $3\sigma_{ys}$ away, will encompass percentages of the total number of points on the graph corresponding to the appropriate normal curve areas.

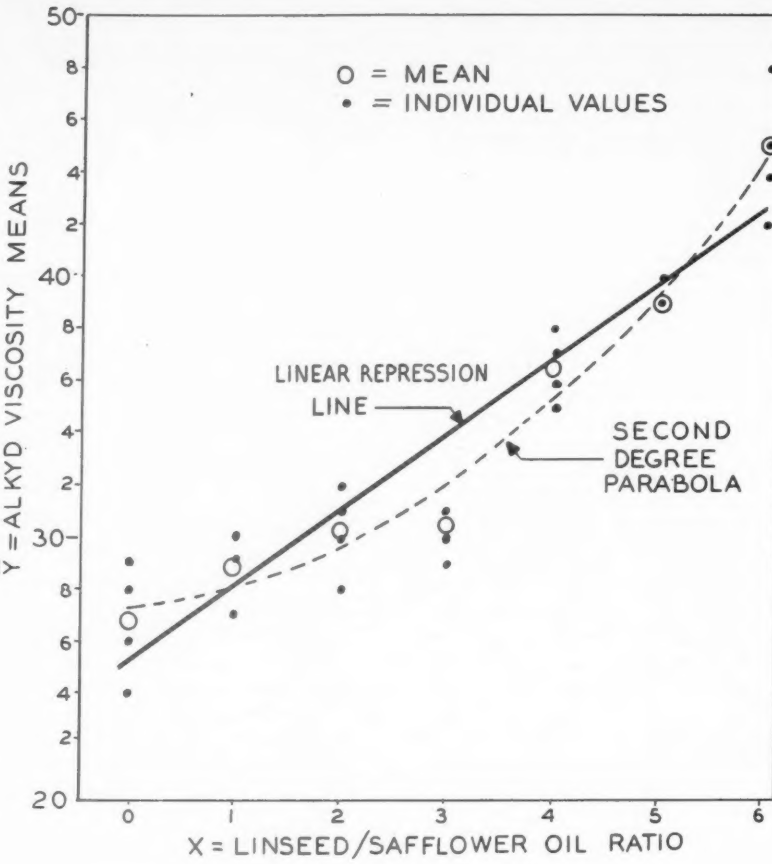


Figure 7. Alkyd Viscosity vs. Oil Ratio—Fitting regression lines.

Again considering the means only, the calculated variances which pertain to the fitting of the line to the 7 means are given:

VARIANCE - UNEXPLAINED	$= \sigma_{ys}^2 = \frac{\Sigma(\bar{Y} - \bar{Y}_F)^2}{N}$	$= 2.86$	7.9%
VARIANCE - EXPLAINED	$= \sigma_{yF}^2 = \frac{\Sigma \bar{Y}_F - \bar{\bar{Y}}^2}{N}$	$= 33.35$	92.1%
VARIANCE - TOTAL	$= \sigma_Y^2 = \frac{\Sigma(\bar{Y} - \bar{\bar{Y}})^2}{N}$	$= 36.21$	100.0%

From this data, *coefficient of determination*—revealing the percentage of the variance explained—is 0.921, or 92.1%. The *coefficient of correlation*, r, is the square root of the coefficient of determination, and is equal to 0.960 or 96.0%.

It is interesting to note that, although the F test shows that a linear regression leaves a significant part of the variation unexplained, the correlation coefficient indicates that the straight line is a good fit. This seeming discrepancy is due to the fact that the r we calculated was based on the viscosity *means*, whereas the analysis of variance was influenced by all the replicate data.

Since an equation of the form $Y_F = a + b\,X$ did not satisfactorily fit the data, a second degree parabola, $Y = a + b\,X + c\,X^2$, was then

Source of Variance	Sum of Squares	D.F.	Variance
Between Columns	1013	6	168.8
Within Columns	58	21	2.8
Total	1071	27	

Table 22

	X	$\overline{Y}$	X^2	$\overline{Y}^2$	$X\overline{Y}$	$\overline{Y}_F$
	0	26.75	0	715.6	0	25.15
	1	28.75	1	826.6	28.75	28.08
	2	30.25	4	915.1	60.50	30.91
	3	30.50	9	930.3	91.50	33.79
	4	36.50	16	1332.3	146.00	36.67
	5	39.00	25	1521.0	195.00	39.55
	6	44.75	36	2002.6	268.50	42.43
Total	21	236.50	91	8243.5	790.25	

Table 23. Alkyd Viscosities—Regression Table.

fitted. The normal equations (not shown here) are derived in a manner similar to these of the straight line. The resulting equation was:

$Y_F = 27.234 + 0.364\ X + 0.420\ X^2$

This equation is plotted in Figure 7 and shows an excellent fit. The analysis of variance (not shown here) calculated an incremental explained variance, due to the additional constant, c, in the parabola, of 59.0, leaving a resultant unexplained variance of 5.25 (DF=4) to be tested against our error variance, 2.8 (DF=21).

Then $F = \frac{5.25}{2.8} = 1.875$, which is not significant at the 5% level. Therefore, the second degree parabola is evidence of a significant.

As a comparison, the correlation coefficient yielded by the parabola was 0.989 or 98.9%.

The technique of regression analysis is a powerful one and the reader will find it exceedingly useful once its workings are understood.

Ranking

Quite often we are confronted with the problem of assessing the relative quality of factors or effects which are difficult or impractical to express quantitatively, such as odor, taste, general appearance, etc. In this case, ranking methods have been widely used—but not so widely analyzed in a systematic fashion.

A scheme for accomplishing this end is illustrated as follows: Consider the ranking of the odors of 10 paints on a relative odor scale, with 0 being assigned to the paint with the least objectionable odor and 10 to the paint with the most objectionable odor. In your laboratory you have 3 chemists who have a good "nose" for odor, from their association with various and sundry organic chemicals. They would have more of a tendency to give an objective evaluation of odor—which is what is wanted in this particular test. Also we are interested in how well these 3 men agree among themselves. The results of the test are shown below in Table 25.

Spearman has suggested a rank correlation coefficient, ρ_r, for determining correlations in this type of experiment.

$$\rho_r = 1 - \frac{\Sigma D^2}{2N\sigma^2} = 1 - \frac{6\Sigma D^2}{N(N^2-1)} \quad (43)$$

where D = the difference between these ratings of a pair of chemist for each paint and N = Number of paints

Source of Variance	Sum of Squares	D.F.	Variance
Not explained by line	80.2	5	16
Explained	933	1	933
Total—variation between columns	1013	6	

Table 24

The values for D and D^2 have been calculated and are shown in Table 25. The resulting rank correlation coefficients are:

$$\text{FOR A \& B} \quad \rho_r = -0.212$$

$$\text{FOR B \& C} \quad \rho_r = -0.297$$

$$\text{FOR A \& C} \quad \rho_r = 0.636$$

Therefore, because of their high correlation, chemists A & C have the nearest approach to common judgement. This will be borne in mind in subsequent test situations.

Blocks

Blocking refers to the pairing or coupling of measurements into sets for replication and for intercomparison by such techniques as analysis of variance. In the pentaerythritol experiment, the 5 tests on 1 batch of PE constituted a block since they were performed in 1 day. If samples from each lot of PE are assigned in some random order to the reaction flask, the blocks will be randomized, which will be helpful in preventing some overlooked effect from becoming identified with an experimental factor. Youden has a complete treatment of blocks and related designs in his book. (5)

Many blocks are complete blocks; that is they have an equal number of classes in all factors—such as the latin square. However, in certain instances it is possible to get around the condition that there must be an equal number of classes in all three factors (5). It may be desired, for example, to intercompare seven varnish thermometers. Suppose that it is possible to mount only three thermometers in the bath so that they can be read with an optical aid in an overall time period short enough to insure an absence of pronounced drift in the bath temperature. An arrangement is available which lends itself to this situation. The seven thermometers are represented below by letters.

ORDER OF READING	RUN No. 1	2	3	4	5	6	7
I	A	B	C	D	E	F	G
II	B	D	F	E	G	A	C
III	C	F	E	A	B	G	D

Paint No.	Chemists			A vs. B		B vs. C		A vs. C	
	A	B	C	$\|D\|$	D^2	$\|D\|$	D^2	$\|D\|$	D^2
1	1	3	6	2	4	3	9	5	25
2	6	5	4	1	1	1	1	2	4
3	5	8	9	3	9	1	1	4	16
4	10	4	8	6	34	4	16	2	4
5	3	7	1	4	16	6	36	2	4
6	2	10	2	8	64	8	64	0	0
7	4	2	3	2	4	1	1	1	1
8	9	1	10	8	64	9	81	1	1
9	7	6	5	1	1	1	1	2	4
10	8	9	7	1	1	2	4	1	1
Σ					200		214		60

Table 25. Ranking Table—Paint Odor Tests.

There are seven runs, each with three thermometers, making a total of twenty-one readings. The order of reading is taken into consideration by seeing to it that every one of the seven thermometers gets the first, the second, and the third readings. It would at first seem that trouble would be encountered if the bath settings are different for the seven runs. The selection of the seven trials has been guided with a view to overcoming this difficulty and, in fact, making it unnecessary to strive to reproduce exactly the temperature in each of the seven runs. It is not so easy to repeat the temperature, and any attempt to do so requires reading a reference thermometer which must remain in the bath for all runs.

It may be that a standard reference thermometer has been used to read the bath each time. In that event the sum of all twenty-one readings on the thermometers under test may be compared with 3 times the sum of the seven readings taken with the standard thermometer. The difference between these sums divided by 21 will give the average correction so that absolute corrections to the thermometers may be obtained.

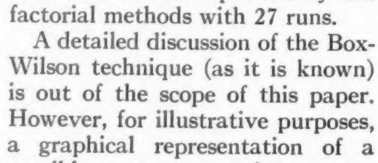
Another, and perhaps more simple, way to get the absolute corrections is to replace one of the test thermometers by the standard thermometer. The absolute correction for the standard is known, and as all the corrections are known relative to each other, it is easy to obtain absolute corrections for all thermometers.

This type of arrangement makes it possible to intercompare a large number of items without the necessity of maintaining conditions constant longer than is required to compare a small number of items. The task of the experimenter is made easier, and the results are often better than they otherwise would be.

Optimization of Results—Response Surfaces

Experiments in a chemical pilot plant usually consist of a series of runs under various conditions in order to find a set of optimum conditions from the point of view of yield, cost, undesirable side reactions, etc. (3, 10, 11, 13, 14, 39, 56). In the past, factorial designs have been recommended for this purpose, in which various combinations of factors are studied at several levels. A systematic plan of this kind often involves a considerable number of runs. As we have seen, a study of 3 factors such as pressure, temperature, and concentration at 3 levels requires 27 runs. It was suggested by the English statistician, G. E. P. Box, that the desired end could be accomplished more economically by making fewer runs at certain specified levels, and fitting a surface to the observed values by the method of least squares. The procedure of fitting a line or curve to a series of observed values is fairly familiar in two dimensions. The fitting of a surface in more than two dimensions is an extension of this procedure which requires the use of matrix algebra. The result is an equation which predicts the yield under any set of the conditions studied, provided extrapolation beyond the region investigated is avoided. In the case of 3 factors at 3 levels, a better job can be done by the Box Method with 17 runs than can be accomplished by the factorial methods with 27 runs.

A detailed discussion of the Box-Wilson technique (as it is known) is out of the scope of this paper. However, for illustrative purposes, a graphical representation of a possible response surface corresponding to the solution of an equation relating the yield, Y, to the temperature, X_1, and catalyst concentration X_2, in a polymerization study is shown below (10).



In practical application (3) an equational relationship of this nature can allow for a marked degree of flexibility in the establishment of the levels of the variables to be used in the actual production. Thus, if for any reason, it is necessary to restrict the level of one of the variables to a specific value or even an interval of values, the other variable may then be adjusted such that approximately the same maximum yield is obtained. In addition, flexibility of this nature can allow the manufacturer to set the variables at levels which give approximately the maximum yield, and minimize the total cost.

As has been already emphasized, studies of response systems are not confined to investigation of only yield. Other dependent variables, such as purity, can be studied. In many instances it is highly desirable to execute simultaneous or even separate investigation of the

response system for yield and the response system for purity. If the system for yield is of the ridge type, it has been demonstrated that by judicious interpretation of both the yield and purity response systems, it is then possible to select levels of the variables such that the yield is approximately maximum and the purity is better than some necessary pre-selected limitation, or even select levels of the variables which result in maximum yield and maximum purity.

Similar contour curves—called triaxular diagrams—are illustrated by Grinsfelder (11). These show the relationship among 3 variables as contours on triangular coordinate paper—with the contours representing isobars of some quality effect desired such as toughness, or yield. This type of chart is simple to construct and is very useful for visual representation.

Decision Making—
Number of Tests to Run

Making decisions is hard work (56). We extol the traits of coolness under stress, of objectivity in the face of emotional and irrational pressures, and of crisp but considered judgments when time is fleeting.

It is no wonder, in this age of communication at the speed of light and transportation at the speed of sound, that scientists are striving to find mathematically rational systems to take over at least some of the load of stressful decision-making.

No pretense is made here that the mathematical scientists have solved the decision-making problem—indeed they have barely started on its formulation. However, there is a rapidly-growing and impressively solid scientific literature that deals mathematically with various aspects of the familiar problem of choosing well between alternatives.

Dr. Merrill M. Flood, at a recent research conference (56), has discussed some of these attempts to focus a scientific eye on decision-making through the statistical lenses of such techniques as Neumann's "Theory of Games", minimax procedures and Box-Wilson techniques for optimization.

Many managements are now using these techniques or modifications of similar methods in a variety of problems—ranging from market research and the prediction of sales to maximization of product yield and research and development efforts (57).

Specified Probability (P*)	Number of Populations						
	k = 2	k = 3	k = 4	k = 5	k = 6	k = 7	k = 8
0.99	3.2900	3.6173	3.7970	3.9196	4.0121	4.0861	4.1475
0.98	2.9045	3.2533	3.4432	3.5722	3.6692	3.7466	3.8107
0.97	2.6598	3.0232	3.2198	3.3529	3.4528	3.5324	3.5982
0.96	2.4759	2.8504	3.0522	3.1885	3.2906	3.3719	3.4390
0.95	2.3262	2.7101	2.9162	3.0552	3.1591	3.2417	3.3099
0.94	2.1988	2.5909	2.8007	2.9419	3.0474	3.1311	3.2002
0.93	2.0871	2.4865	2.6996	2.8428	2.9496	3.0344	3.1043
0.92	1.9871	2.3931	2.6092	2.7542	2.8623	2.9479	3.0186
0.91	1.8961	2.3082	2.5271	2.6737	2.7829	2.8694	2.9407
0.90	1.8124	2.2302	2.4516	2.5997	2.7100	2.7972	2.8691
0.88	1.6617	2.0899	2.3159	2.4668	2.5789	2.6676	2.7406
0.86	1.5278	1.9655	2.1956	2.3489	2.4627	2.5527	2.6266
0.84	1.4064	1.8527	2.0867	2.2423	2.3576	2.4486	2.5235
0.82	1.2945	1.7490	1.9865	2.1441	2.2609	2.3530	2.4286
0.80	1.1902	1.6524	1.8932	2.0528	2.1709	2.2639	2.3403
0.75	0.9539	1.4338	1.6822	1.8463	1.9674	2.0626	2.1407
0.70	0.7416	1.2380	1.4933	1.6614	1.7852	1.8824	1.9621
0.65	0.5449	1.0568	1.3186	1.4905	1.6168	1.7159	1.7970
0.60	0.3583	0.8852	1.1532	1.3287	1.4575	1.5583	1.6407
0.55	0.1777	0.7194	0.9936	1.1726	1.3037	1.4062	1.4899
0.50	0.0000	0.5565	0.8368	1.0193	1.1526	1.2568	1.3418
0.45		0.3939	0.6803	0.8662	1.0019	1.1078	1.1941
0.40		0.2289	0.5215	0.7111	0.8491	0.9567	1.0443
0.35		0.0585	0.3578	0.5510	0.6915	0.8008	0.8897
0.30			0.1855	0.3827	0.5257	0.6369	0.7272
0.25			0.0000	0.2014	0.3472	0.4604	0.5523
0.20				0.0000	0.1489	0.2643	0.3579
0.15						0.0364	0.1319
0.10							
0.05							

Table 26. Multiple Decisions. Table of $\sqrt{N}$ corresponding to various probabilities, to be used for designing experiments involving k normal populations to decide which one has the largest (or smallest) population mean.

As an example of this type of thinking, we will consider situations in which management is desirous of making decisions between alternates.

When running a series of tests to determine whether 2 or more sets of samples or types of processes are equivalent or are different, it always imperative to know at what point to stop sampling or testing. Sampling and testing programs are quite expensive in the manner in which they tie up and expend manpower, materials and time. Several methods have been proposed to estimate the number of tests required to determine significance of differences. These are described below:

Replication

Grinsfelder suggests the following equation as a rough approximation: (11)

$$N = \left(\frac{t\sigma}{D}\right)^2 \qquad (44)$$

where N = the number of replicate tests

σ = the standard deviation of the measurements

D = the difference (between sample means) worth looking for

t = Student's t from Table 6.

Inasmuch as t is related to N, the above equation is best solved by trial and error methods. This equation will be used later in a sampling problem.

Multiple Decision Procedures

Procedures for determining the most economical way to sample parent populations have been widely studied by some of our most capable statisticians under several government contracts. Bechhofer, of Cornell University, has published several methods of ranking

2 or more populations, the least complicated of which (the single sample procefure) can be illustrated by the following example (55).

To select the largest out of k population means.

Let $\delta_{k,k-1}$ represent the true (but unknown) difference between the largest and the next largest of the k population means. It is assumed that the experimenter can specify the following before experimentation starts:

(1) The smallest value of $\delta_{k,k-1}$, say δ^* greater than zero, that he is interested in detecting

(2) The smallest acceptable value, say P^* less than 1, of the probability P of achieving this goal when $\delta_{k,k-1}$ is equal to or greater than δ^*.

In this case we assume that all the populations have the same known variance, σ^2. Bechhofer has calculated a table (Table 26) which relates $P^*\delta^*\sigma$ to a quantity $\lambda\sqrt{N_e}$, where N_e is the number of observations required and $\lambda = \frac{\delta^*}{\sigma}$

Consider 3 normal populations with a common known variance. These could be represented by 3 tankcars of linseed oil. The quality characteristic being measured is iodine value. It is desired to select the car with the highest average iodine value and to guarantee that the probability of a correct selection is at least 90% when the true difference in iodine values is equal to or greater than 0.4 units. If $\sigma = 2.0$ units (based on past experience), how many observations must be taken from each car?

For $k = 3$ and $P^* = 0.90$, Table 26 yields a value of $\lambda\sqrt{N_e} = 2.2302$. Since $\lambda = \frac{0.4}{2.0}$ or 0.2, we obtain the equation $0.2\sqrt{N_e} = 2.2302$, or $N_e = 124.34$. We conclude that for the conditions specified 125 samples must be taken from each population.

Since N here is absurdly and prohibitively large, the person in management specifying limits must choose a smaller P^* and/or a larger δ^*. Here, knowing the significance of the iodine values in our operations, we could apparently tolerate a δ^* of 2.0. Then $\lambda = \frac{2.0}{2.0} = 1.0$, $2.2302 = \sqrt{N_e}$ and $N_e = 4.99$ or 5—a more reasonable figure for the type of analysis involved.

Notice the vital part played by the manager in this problem since he must decide the risks involved in seeking specific differences.

Sequential Testing

A very powerful method open to the experimentalist is that known as the sequential test. This method has the advantage that, as its name implies, each result is considered as it becomes available, and testing ceases just as soon as the necessary data is available to arrive at a decision. This is best explained by an example (45).

Consider a study of the drying time of linseed oil in the summer and in the winter, under uncontrolled, ambient laboratory conditions. Ten summer results have been obtained as shown:

	Drying Time—hours
1	7.0
2	5.5
3	5.0
4	6.0
5	5.5
6	6.0
7	5.0
8	7.5
9	7.5
10	5.0
$\bar{X}_o$	6.0
σ	1.00

The mean of the summer results, $\bar{X}_o$, is 6.0 hours and this is the time from which it is desired to know whether the winter figure differs. The mean of the winter figures that we will determine is $\bar{X}_1$. $\bar{X}_1 - \bar{X}_o = \delta$, which is the difference that we are trying to detect—in this case, one hour. It should be noted that here it is possible to state in advance the magnitude of the difference that is of practical consequence. The standard deviation of the results, σ, is one hour.

At this stage, certain decisions have to be made on risks. There are 2 types of risks: that of asserting there is a difference when none exists, and the opposite—that is saying there is no difference when one does exist. These risks may be expressed in the form of probabilities, a low probability, such as 0.01, meaning little risk and a higher probability, such as 0.1, meaning a larger risk.

In this assessment of risk lies one of the great advantages of the method to the experimentalist. By setting the first risk, α, low he reduces his chance of saying there is a difference when none exists, and by setting it high, he may report a difference when in fact no such difference exists. In the latter case this would result in additional work—only to find later that there was no difference and the additional effort had been wasted. On the other hand, by setting the second risk, β, low, the chances of not detecting the difference are minute—bearing in mind that even a small difference may be critical.

In this example, the values of α and β chosen are 0.05 and 0.01 respectively. The procedure then is as follows: Calculate first the following values a, b, h_0, h_1, and s:

$$a = \ln\frac{(1-\beta)}{\alpha} \tag{45}$$

$$b = \ln\frac{(1-\alpha)}{\beta} \tag{46}$$

$$h_o = \frac{-b\sigma^2}{\delta} \tag{47}$$

$$h_1 = \frac{a\sigma^2}{\delta} \tag{48}$$

$$s = \frac{\bar{X}_0 + \bar{X}_1}{2} \tag{49}$$

(Tables exist for the values of a and b.) For the values chosen here, $a = 2.986$ and $b = 4.554$. Substituting in equations (47, 48, 49) we get these results

$h_o = -4.554$, $h_1 = 2.986$, $s = 6.5$

The sequential method then consists in comparing the cumulative values of the drying times obtained with the 2 limits given by the following equations:

$$T_0 = h_0 + ns \tag{50}$$

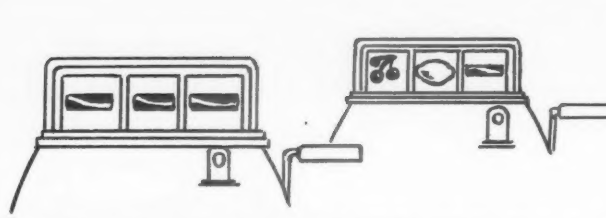
$$T_1 = h_1 + ns \tag{51}$$

For our case, these equations are as follows:

$T_o = -4.554 + 6.5\ n$

and $T_1 = 2.986 + 6.5\ n$

where n is the number of tests con-



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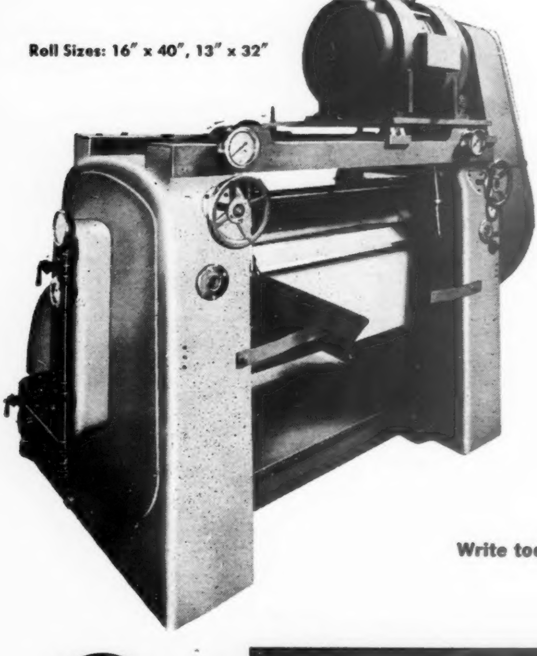

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ducted. The following table shows the number of tests, n, T_o, T_1, and T—the actual experimental cumulative total obtained by summing up the drying times as they are measured.

Cumulative Totals

n	T_o	T	T_1
1	1.95	6.0	9.49
2	8.45	14.0	15.99
3	14.95	21.5	22.49
4	21.45	27.5	28.99
5	27.95	35.0	35.49
6	34.45	41.5	41.99
7	40.95	49.5	48.49

Inspection of this table shows that at all values of n from 1 to 6, the value of T lies between that of T_o and T_1, but after the 7th result is obtained, the value of T exceeded that of T_1, the higher limit. Therefore, it was immediately concluded that the winter drying time was longer than that of the summer

Courtesy of Remington Rand Inc.

Automatic printing calculator is said to calculate, prove, print on tape problems involving multiplication, division, addition, subtraction.

by at least one hour on the average. When this experiment was run elsewhere, the same original 10 experiments were required to achieve this result. Therefore, the answer to the question posed has been obtained with only 7 results instead of 10. This is a general finding of the sequential method—namely, that fewer experiments are required than the normal method, providing always that the risks and the required difference are not set too low.

The above data is plotted in Figure 8, where the 2 limit lines are shown as parallel lines, and the test data is shown between them, crossing the T_1 line at $n=6.4$.

This completes our discussion of the statistical tools which we can use to help us increase our experimental efficiency, precision and accuracy. The next section will introduce us to further applications of these various techniques.

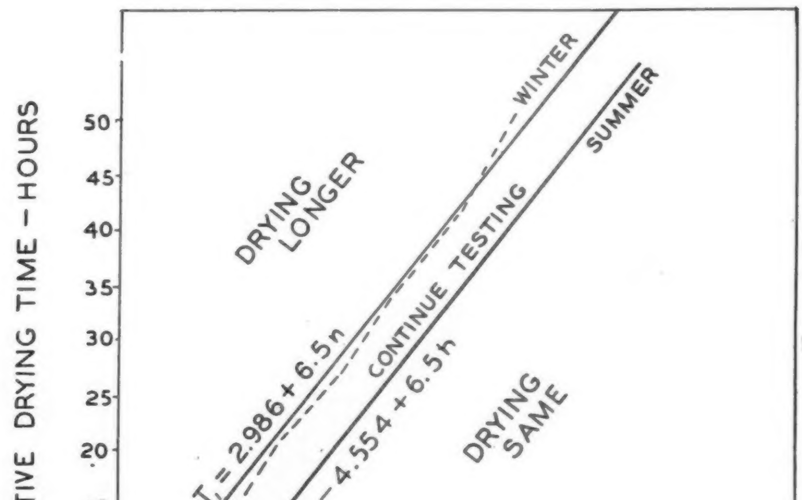

Figure 8. Drying times—Sequestial testing.

APPLICATION and DEVELOPMENT

IN THIS section, we will show further examples of how several of the statistical methods we have discussed have been applied in various laboratories.

Experimental Design

It can be well appreciated that in these times of high labor costs and critical manpower shortages, economy of design can be of great value in saving development time, and money. Our goal should always be to so increase the efficiency of our experiments that we may extract the maximum amount of results and significance from the minimum number of tests. This was done in the previously discussed latin square experiment on skinning—where we accomplished in 16 experiments what would have required 64 trials by conventional methods.

Tests and Test Methods

Another experiment which can be performed on a latin square basis is a salt spray test. It is desired to study three different undercoats (C_1, C_2, C_3), three different baking schedules (S_1, S_2, S_3) and three different finish coats (F_1, F_2, F_3). Nine experimental panels may be prepared so that there are 3 panels with each undercoat, and all 3 baking schedules are used with each undercoat. The 9 panel combinations are tabulated so that each undercoat appears as a row and each baking schedule as a column. The finish coats are applied as shown below so that all 3 finish coats appear in every row and column.

This Latin Square arrangements allows each finish to be tried with each undercoat at each bake.

	S_1	S_2	S_3
C_1	F_1	F_2	F_3
C_2	F_3	F_1	F_2
C_3	F_2	F_3	F_1

Analysis of variance of the 9 salt spray results obtained will have as much meaning as if the full number of panels were prepared (27).

By replication of the complete square, the experimental error of the salt spray test can be determined accurately.

Youden (5) discusses many uses for statistical techniques in assessing tests, methods and instruments. Other recent articles (16, 2) give excellent discussions of the use of analysis of variance on the intercomparison of 2 different paper smoothness testers and for 2 thickness tests. ASTM Symposia are often held on the subject of instrumental testing, standardization and correlation. (59)

Factorials

The applications of factorial analysis to coatings development and testing are growing steadily as shown by numerous references in the recent literature.

An interesting and extensive series of analyses on pigment oil absorption was recently made by Bainbridge in Australia. (48) The factorial analysis evaluated the effect on oil absorption of different types of pigments, types of glass plates and operators. Some of the results were:

(1) Porcelain plates give oil absorption 8% higher than ground glass plates for all pigments and operators concerned. This difference is highly significant.

(2) A given operator can reproduce his work with a standard error of about 3 per cent. When triplicate tests are made some operators appear to be unable to retain independence in their work and the second and third results are drawn unjustifiably close to the first!

When conditions are changed, e.g., by use of a different pigment, but not by use of a different type of plate, an additional source of uncertainty having a standard error of about 10 per cent, is introduced.

The differences between the work of different operators is adequately explained by these two errors.

In the paint and varnish laboratory a great saving of time and experiments can be made using factorial analysis (47), and the general effects of variations in factors rapidly and exactly assessed, amply repaying the time involved in calculating the results. The factorial method is ideally suited for such experiments as evaluating the effects of drier mixtures, investigating varnish and resin making processes, studying the effects of pigment combinations on the properties of dispersions, extender studies, monomer ratios vs tensile strengths and elongation of films deposited from

latices, color, color development and color retention studies on fatty acids and alkyds and white enamels made therefrom.

Certainly these and many more test situations will suggest themselves to you as you read this discussion. There are many adaptations of the factorial method, suitable for almost any number of experiments and references to standard handbooks, (10, 20) will be found useful in choosing a design and carrying out the mathematical computations.

Exposure Testing

This is a field which has been crying for statistical analysis ever since the first series of panels was exposed on the first test fence. Touchin has added greatly to an understanding of the problems involved and has shown several worked out designs in 2 recent articles. (52, 53)

The possible sources of experimental error in exposure trials are many, but the following are thought to provide the main variables:

(1) The preparation of the finishes.
(2) The panels.
(3) The human element in panel preparation.
(4) The conditions during painting.
(5) The conditions during drying.
(6) The ageing period before exposure.
(7) The location of the exposure site.
(8) The type of rack.
(9) The position of the panel on the rack.
(10) The weather immediately after exposure.
(11) The weather over the complete period of the test.
(12) The human element in assessing breakdown.

There are two methods open to the investigator to allow for these possible sources of variation. The first is that normally employed, i.e. controlling the conditions as closely as possible. Yet, whatever degree of care and experimental skill is expended in equalizing the conditions other than those under examination, this equalization must always be more or less incomplete and in the present instance, will be grossly defective. The second alternative is to include the variables in the design of the experiment in such a way that they exert no bias, i.e. their effect on any unit can be attributed solely to the normal operation of chance, or that they can be eliminated from the statistical analysis of the results. With as many factors as are suggested above, the latter method would result in excessively complicated designs, so resource has to be made to all the methods in most cases.

The usual attack is to randomize what factors on variables we cannot feasibly control, vary the factors we can control in an appropriate experimental design, and analyze the results. The randomized, uncontrolled factors will of course contribute to the residual error terms in our analysis of variance.

Touchin discusses in detail the use of latin squares, factorials, randomized blocks, split plot designs, regression and the role of replication. He has contributed considerable enlightment on a very old problem—the correlation between exterior exposure data and accelerated weathering data. In (52) he analyzes chalking data presented by the Cleveland Paint and Varnish Club (Official Digest 1945, 1946, 1948)—but unfortunately not analyzed at that time. While he confirms the fact that good correlations exist (r—ranges from 0.860 to 0.954), he is able to show that there is no evidence of any difference between the weatherometers other than would be obtained by chance in the correlation between the machines and Florida exposure.

Another recent study (4) concerned accelerating blistering tests on exterior white house paints. Analysis of variance of the data showed no significant correlation between permeability and blistering.

The use of statistical methods in exposure trials has several attributes to recommend it. Primarily, they enable more information to be obtained for a given amount of work, and the extent of the errors involved in any experiment are known. They make exposure trials more efficient. They enable correlation between variables to be studied, and as an extension of this principle, they suggest the possibility of combining data into single values. The difficulty of measuring breakdown, except by subjective assessment, places some limitations on the methods, but does not invalidate them.

It must be emphasized that only when experiments have been suitably designed are they amenable to statistical analysis. It is therefore necessary to plan the experiments for statistical treatment from the start.

Odor Testing

In a previous example, odor assessment was discussed using rank correlation techniques. At the Spring 1955 meeting of the ACS in Cincinnati, a Symposium on Odor and Taste Measurements was held, at which 2 of the papers were concerned with the statistical analysis of odor measurements.

In a study of odor quality of isopropyl alcohol (17), involving comparisons between experienced and inexperienced panels, analysis of variance of the results has been used for determining odor acceptability within and between plants.

This procedure has made it possible to maintain a high odor of interchangeability of source of supply on a nationwide basis for uses where odor is important. Substantial improvements in overall odor quality level have also resulted since improved uniformity has been achieved by changes in plant operation which bring the poorest quality producer closer to the best.

In another paper (7), the author evaluated the odor level of several odorless flat wall paints. Here extensive testing of the averages of 20 panel members showed significant differences among the odors of from 3 to 6 paints. It is important to point out that odor testing could be treacherous when applied to too large a number of paints. This is because of the considerable fatigue or deadening of the olfactory senses that usually occurs when going from one sample to the next in an odor test. The test referred to previously may be considered an exception (10 paints) because experienced chemists were involved. However, consciously or otherwise, they could be guilty of

inserting biases into the results, which account for the differences shown.

Balanced Incomplete Blocks

In a recent paper (18), a study was made of cold check resistance of nine furniture lacquers on plywood panels. Two test lacquers were used on each panel and the tests were designed as a balanced incomplete block arrangement for the 9 lacquers with treatment in blocks of 2 and with each pair occurring together once.

One cold-check cycle consisted of 1 hour in a forced circulation dryer at 110° F., 1 hour in a freezer maintained at −5° F., and 1 hour for removal of surface condensate and an examination for checks. The plywood panels were placed in racks to facilitate handling and air circulation. Within 30 minutes after placing the panels in the freezer, the temperature had returned to −5° F.

After each hot-cold cycle, the panels were examined under an intense oblique spotlight covering the entire double panel. When checks appeared, the panel was recorded as having failed at the cycle completed. Eight cold-check cycle values were obtained for each lacquer as shown in Table 27.

	Lacquers									
Panels	1	2	3	4	5	6	7	8	9	Totals
1	3	3								6
2	4		12							16
3	2			2						4
4	6				18					24
5	7					16				23
6	2						9			11
7	3							7		10
8	7								19	26
9		3	4							7
10		6		5						11
11		4			11					15
12		4				5				9
13		2					10			12
14		4						4		8
15		3							9	12
16			4	7						11
17			4		10					14
18			4			7				11
19			11				16			27
20			6					5		11
21			14						14	28
22				4	3					7
23				13		6				19
24				3			3			6
25				7				3		10
26				7					4	11
27					12	16				28
28					14		16			30
29					11			4		15
30					6				17	23
31						13	9			22
32						12		4		16
33						13			13	26
34							11	3		14
35							19		15	34
36								3	17	20
Totals	34	29	59	48	85	88	93	33	108	577

Table 27. Lacquer cold check resistance cycles.

The average cold check cycles for each lacquer, adjusted for panel differences was calculated as follows:

If the simple arithmetic average of the eight results for Lacquer No. 1 is compared with that for any other lacquer, the difference is influenced by the fact that, except for the one panel on which both appear, the two lacquers are on different panels. The lacquer averages, however, may all be "adjusted" so that they are influenced to exactly the same extent by inherent panel-to-panel differences. The adjustment formula is

$$\text{Adj Avg.} = \frac{2L_i \quad \Sigma P_j}{9} + \text{Grand Avg.} \qquad (52)$$

where L_i is the sum of the eight values for the i^{th} lacquer and P_j is the sum of all sixteen observations for the eight panels on which the i^{th} lacquer occurs.

A sample calculation for Lacquer #1 follows:

$$\text{The grand average} = \frac{577}{72} = 8.01,$$

$L_i = 34$, $P_j = 120$.

Therefore, Adj. Avg. =

$$\frac{(2)(34) - 120}{9} + 8.01$$

$$= -\frac{52}{9} + 8.01 = 2.23$$

Up and Down Method

The 9 lacquers were applied to tinplate and tested further for flexibility over 11 mandrels, ranging from 1/8″ to 1 1/2″.

Bending mandrel tests were conducted according to a sequential statistical technique called the "up-and-down" method. Fifteen metal plates were coated for each lacquer. After each bend the coating was examined visually for evidence of cracking and recorded as X if cracked or O if not cracked. If the film cracked, the next larger diameter mandrel was used for bending a new specimen. If the film did not fail, the next smaller diameter mandrel was used. The results are shown in Table 28.

In applying a bending mandrel type of test it is assumed that for each lacquer there is some particular mandrel size over which fifty percent of the specimens tested would crack and fifty percent would not. For smaller mandrel sizes the probability of a specimen cracking is greater than fifty percent; for larger mandrel sizes it is less than fifty percent. The fifty percent mandrel size is a means of characterizing the lacquer. The principal advantage of the sequential "up-and-down" method is that it automatically concentrates the testing in the neighborhood of the fifty percent mandrel size, thus leading to a more efficient estimate of this value. The actual estimate is made by averaging the levels at which the tests were run *omitting the first* and *including the*

level at which the next test would have been run had one more specimen been tested. The values thus calculated are given in Table 29. (together with the adjusted average cold check cycles from the previous test).

A typical calculation for the flexibility test is: (for lacquer #1, Table 28.) Neglect panel #1 and add a reading at the 1.125 in. level.

$$\begin{array}{rcl} 4 \text{ at } 0.875 & = & 3.5 \\ 6 \text{ at } 1.000 & = & 6.0 \\ 4 \text{ at } 1.125 & = & 4.5 \\ 1 \text{ at } 1.25 & = & 1.25 \\ \hline 15 & & 15.25 \end{array}$$

$$\text{Adj. Average} = \frac{15.25}{15} = 1.017$$

Of course, if a conical mandrel was available, the up-and-down method of testing would not have been required. However, its application in this case is a good illustration of a simple and useful method.

A linear regression equation was eventually calculated relating the 2 variables, X (average Mandrel size in inches) and Y (average adjusted cold check cycles):

$$Y = 15.44 - 12.29\,X$$

(1) The authors concluded that a close correlation was found between lacquers subjected to cold-check cyclic tests and bending mandrel flexibility tests. Lacquers with low cold check resistance would fail on bending over large diameter mandrels. High check resistant lacquers coated on metal plates could be bent on small diameter mandrels indicating greater flexibility or plasticity.

(2) The close relationship between cold-check cycles and bending mandrel flexibility tests indicates that bending mandrels can be substituted for the tedious, costly, time-consuming cold-check cycle tests for lacquer films.

(3) Bending mandrel tests can be conducted in one day and are recommended for laboratory control of check resistance of lacquer-resin finishing materials.

Pilot Plant Studies

In pilot plant operations, statistically designed experiments can yield fruitful results. The application of any or all of the above

Lacquer	Mandrel Size (Inches)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	.875		X						X		X				X	
	1.00	0		X				0		0		X		0		X
	1.125				X		0						0			
	1.25					0										
2	.75				X						X				X	
	.875	X		0		X		X		0		X		0		X
	1.00		0				0		0				0			
3	.50							X		X		X		X		
	.625		X		X		0		0		0		0		X	
	.75	0		0		0										0
4	.375													X		
	.50		X		X				X		X		0		X	
	.625	0		0		X		0		0		0				0
	.75							0								
5	.25															X
	.375		X		X		X		X		X		X		0	
	.50	0		0		0		0		0		0		0		
	.625															
6	.375	X		X		X		X		X		X		X		X
	.50		0		0		0		0		0		0		0	
7	.125				X		X		X							
	.25	X		0		0		0		X		X				X
	.375		0								0		X		0	
	.50													0		
8	1.00	X										X				
	1.125		X		X		X		X		0		X			
	1.25			0		0		0		0				X		X
	1.375														0	
9	.125				X				X		X		X			
	.25	X		0		X		0		0		0		X		X
	.375		0				0								0	

Table 28. Lacquer flexibility bending mandrel tests.

Lacquer Number	Adjusted Average Cold Check Cycles	Average Mandrel Size - inches
1	2.2	1.017
2	5.6	0.892
3	7.2	0.617
4	9.9	0.558
5	9.6	0.417
6	10.4	0.442
7	11.3	0.283
8	3.8	1.200
9	12.0	0.250

Table 29. Average lacquer test results.

mentioned methods becomes obvious as our familiarity with them increases. Factorials are the favorite designs and have been used in many a study.

The most recent and compelling technique is the Box-Wilson response surface analysis. As previously mentioned, this method is capable of handling many variables at one time, and by a series of small centrally-composited factorials (for replication) determining the path of steepest ascent to the maximum of the effect desired. Eventually a series of contours is mapped on surfaces, corresponding to the number of variables used—and the area encompassing the maximum (unknown) is studied more closely.

Recent Gordon Research Conferences on Statistics have emphasized this type of response surface analysis; Professor Box has written prolifically on the subject and his writings are a must to people desiring to use his magnificant and imaginative methods.

Evaluation of Data

One of the most common areas of application of statistical methods is in round-robin testing as conducted by such organizations as the ASTM, AOCS and Smalley Institute. For example, in the evaluation of the worth of a new test method for rosin acids content of tall oil fatty acids, each laboratory may receive samples of different types of tall oils and they may be asked to run their tests in triplicate. The data may then be collected and an analysis of variance run, testing the variance between laboratories against the variance within laboratories. This will yield knowledge on the precision within laboratories and the reproducibility between laboratories—which information can be used to set appropriate limits and specifications.

The major shortcoming of round-robin work is that complete compliance to the test scheme is rare—usually some laboratory does not replicate its test or does not report its results to the proper number of decimal places. These defections will harm the symmetry of the design and cast doubt on the results of any analysis attempted on the incomplete data.

Concluding this section, one word of warning must be given. (52) In all good experimental work, it is essential to ask the right questions before the right answer can be obtained. In statistical methods, it is essential to know the right questions before the experiment is designed. For it is on the basis of those questions that the work will be laid out, and on this depends not only the answers obtained but the types of answers too. A bad experiment will not become a good one merely because statistical methods are used and they still require the same, and perhaps more, rigorous attention to detail on the part of the experimenter. They should not be used automatically either, for there is little point in making laborious computations where the results are obvious. They are not a panacea for all ills, but a powerful instrument in the hands of those who wish to use it in the cause of progress.

Purchasing - Shipping

All raw materials entering a paint or varnish plant are purchased in conformance with some sort of specification and all finished products leaving the plant are likewise shipped subject to a product specification. It is true that the nature and complexity of these specifications may vary considerably—from a simple color or appearance test to an elaborate, minutely detailed test, as outlined, for example in various government specifications for coatings.

In any event, they were usually established in one of 2 ways:

1) Historically—through compilation of test data on many previous batches and deriving a target value of the average and its limits from an examination of the test data.

2) By accepting a raw material supplier's specification or by adopting a competitor's specifications for a finished product—in order to maintain a proper share of business.

Quite often, these specifications have been set casually—with little imagination, and, by simple longevity, have attained an unimpeachable status. For best results, these limits should be set intelligently, the choice being guided by the inherent variability of the process making the product and the economics of sampling and testing.

Acceptance sampling plans in the "so called" hard goods industry (Metals, Aircraft) have been worked out in great detail and have been thoroughly covered in the literature (6, 19, 24, 25, 58, 59). The chemical industry, including the paint and varnish field, has received somewhat less of a coverage.

Consider the receipt of a carload of bags of a specific grade of whiting. This product is mined directly, subjected to a crude classification process and then bagged. Consequently, differing from synthetic products which are manufactured under close control, it may be subject to large variation.

The unit cost of whiting is small, however, its effect on a paint formulation is large. Therefore, certain quality characteristics of whiting must be known accurately and closely controlled to maximize the quality of our paint production.

We will consider the quality characteristic of oil absorption. Previous lots from this supplier (and others) had been sampled and tested sporadically over the years. Examination of the records and calculations based on the data discovered show the following figures for oil absorption of whiting received:

$$\bar{X} = 16.0$$

$$\sigma = 6.0$$

OUR SPECIFICATION IS 14 TO 18

Suppose that we want to be 95% sure that no bag in the shipment of 1000 bags has an oil absorption less than 14.0 or more than 18.0, we could use one of the many single or sequential sampling plans published (59). However, we could treat this as a multiple decision problem, or-more simply, use the modified t test formula shown before in our replication discussion, equation (44).

$$N = \left(\frac{t\sigma}{D}\right)^2$$

Here, we will use, as an approximation:

$$t \text{ FOR } DF = \infty \text{ AND } 95\% \text{ LEVEL } (p = 0.025 \text{ ONE SIDE})$$

$$t = 1.960 \text{ AND } D = 16 - 14 = 2$$

$$N = \left[\frac{(1.960)\ (6.0)}{2.0}\right]^2 = (5.88)^2 = 34.5$$

$$\text{BY TRIAL AND ERROR } \quad t = 2.04 \text{ FOR } DF = 33.5$$

$$N = \left[\frac{(2.04)(6.0)}{2.0}\right]^2 = 37.5 \text{ OR } 38 \text{ SAMPLES FROM LOT}$$

Therefore 38 sample bags will have to be taken *at random* from the car to establish a difference of 2.0 units of oil absorption (between the previous average and the average of the 38 samples, representing the new lot), as being statistically significant.

Notice that this equation does not consider the total size of the lot to be sampled, as do most of the common sampling plans used in industry. This is also somewhat contrary to the old rule of thumb which states that the number in a sample from a lot should be the square root of the number in the lot.

The sampling for acceptance or rejection of pigments, colors, extenders, oils, resins, latices or thinners can be handled in this way, if the quality of the material is a critical factor in production and consequently must be held within rather narrow limits.

When properly performed, acceptance sampling can save time and money by preventing the acceptance of below standard material. Otherwise, we spot sample for the record, trusting our supplier, his process and reputation, to furnish us with an acceptable product. We have to do a certain amount of buying on faith if we are not to have an exorbitant testing charge. It is simply a question of weighing the risks involved.

In any event, control charts (as shown below) should be maintained on all critical raw materials, wherever possible, so that we may have a constant check on the quality of the product and the direction in which the quality is moving.

Production

Control Charts

The prime consideration in regulating a process is that the product meet the product specifications, at a minimum cost of production. (58)

A second consideration (which is often an essential means of meeting the prime consideration) is that the process be uniform. Obviously "uniform" as used here does not mean that the units of product are precisely alike. Rather it means that the variability in the product is due only to the numerous, small sources of variation contained in any process, rather than to some large, "findable" source of variation.

When the variability in the product is due only to numerous small causes, the process is said to be "in control".

When the variability in the products is due to large, "findable" sources of variation, the process is said to be "out of control".

The determination of whether a process is in control or out of control comes up in two basic ways.

1. The testing of whether an unknown process is in control. This is mainly a test for uniformity, or stability.
2. The testing of whether a process known to have been in control remains in control. This is mainly a test for conformance to a predetermined standard.

The determination of whether an unknown process is in control involves taking a series of samples from the process, and testing these samples for significant differences from the aggregate of all the samples.

The determination of whether a process remains in control involves taking continuous samples from the process, and testing these samples for significant differences from the expected performance of the process.

While this testing can be done by a series of significance tests (see Test for Significance of Differences), Dr. W. A. Shewhart devised, in 1924, a graphic method for doing this testing continuously. (25) This method, known as the Shewhart control chart, or simply as the control chart, is thus a graphic perpetual test of significance. The control chart has been found to have an enormous radius of application, not merely in quality control, but in all forms of continuing tests of significance.

Control charts may be classified as to the characteristic being tested for significance. The more usual charts in quality control are to test (for significance):

1. The average of the measurements in the sample. These control charts are known as X charts.
2. The ranges of the measurements in the sample. These are known as R charts.
3. The standard deriations of the measurements in the sample σ charts.

Consider a filling operation on a new machine in a paint factory, where we are filling gallons of white enamel with an average gross weight (paint and can) of 10.00 lbs. The allowable limits are ± 0.25 lbs. We would like to construct a control chart to systematically keep our process under study.

Let us assume that although we do not yet know the σ of the process, not more than 1 can in 1000 is to fall outside the limits of

9.75 - 10.25 lbs. Therefore, the filling operation should be established so that the average weight will be larger than 9.75 (and smaller than 10.25) by an amount equal to 3σ, since the tail of a normal distribution curve beyond—3σ contains about $\frac{1.3}{1000}$ of the area.

Therefore, if:

$$3\sigma' = 0.25 \text{ LB.}$$

$$\sigma' = 0.083 \text{ LB.}$$

$$\bar{X} = 10.000 \text{ LBS.}$$

It is now possible to estimate the limits within which the means of samples of size N should fall if drawn from the universe of cans. These limits are:

$$\bar{X} \pm 3\sigma_{\bar{x}} \text{ for } 99.73\%$$

of the sample means.

The sample size N, the *Rational Subgroup*—in quality control is usually 4 or 5, within which, variations may be considered due to non-assignable chance causes only (error group) and between which there may be differences due to assignable causes whose presence is considered possible.

LET $N = 4$

$$\sigma_{\bar{x}} = \frac{\sigma'}{\sqrt{N}} = \frac{0.083}{\sqrt{4}} = 0.021$$

AND $3\sigma_{\bar{x}} = 0.063$; $\bar{\bar{x}} \pm 3\sigma_{\bar{x}} = 10.00 \pm 0.063$

Therefore, we construct the control chart for paint can weight averages as follows (Figure 9).

CENTRAL LINE $= \bar{\bar{x}}$	$= 10.00$ LBS.
UPPER CONTROL LIMIT $= \bar{\bar{x}} + 0.063$	$= 10.063$ LBS.
LOWER CONTROL LIMIT $= \bar{\bar{x}} - 0.063$	$= 9.937$ LBS.

Quality Control Engineers have adopted the 3σ limits as an indication of lack of control not so much because of the statistical probability valve of 99.73%, as because these limits have proved to be satisfactory and economical in practice.

We take samples of 4 cans each from the filling operation at regular intervals and plot their averages on the control chart. If one or more of the subgroup averages falls outside the control limits, we take this fact as an indication that the process is not in control. We can then stop the process and attempt to find the cause for the lack of control.

In Figure 9 we have plotted a series of sample readings. At sample 10 we observe the process going out of control, steadily upward. We stopped the operation, examined the machine and found a small amount of skin clogging the opening and causing the paint delivery to be prolonged for a fraction of a second—enough to make the difference. The impediment was removed and subsequent sampling showed that the operation was back in control.

The samples indicate probability only, not certainty. It is quite possible that lack of filling control might exist without being brought to light by this procedure. It is even possible that a sample mean might be well within the control limits and yet the individual cans may be beyond the limits. This could easily be true if the variation within a sample was large.

To further assure satisfactory uniformity, it is desireable also to set up in analogous fashion control limits for the standard deviation (or range) of the samples and to record the results of successive samples.

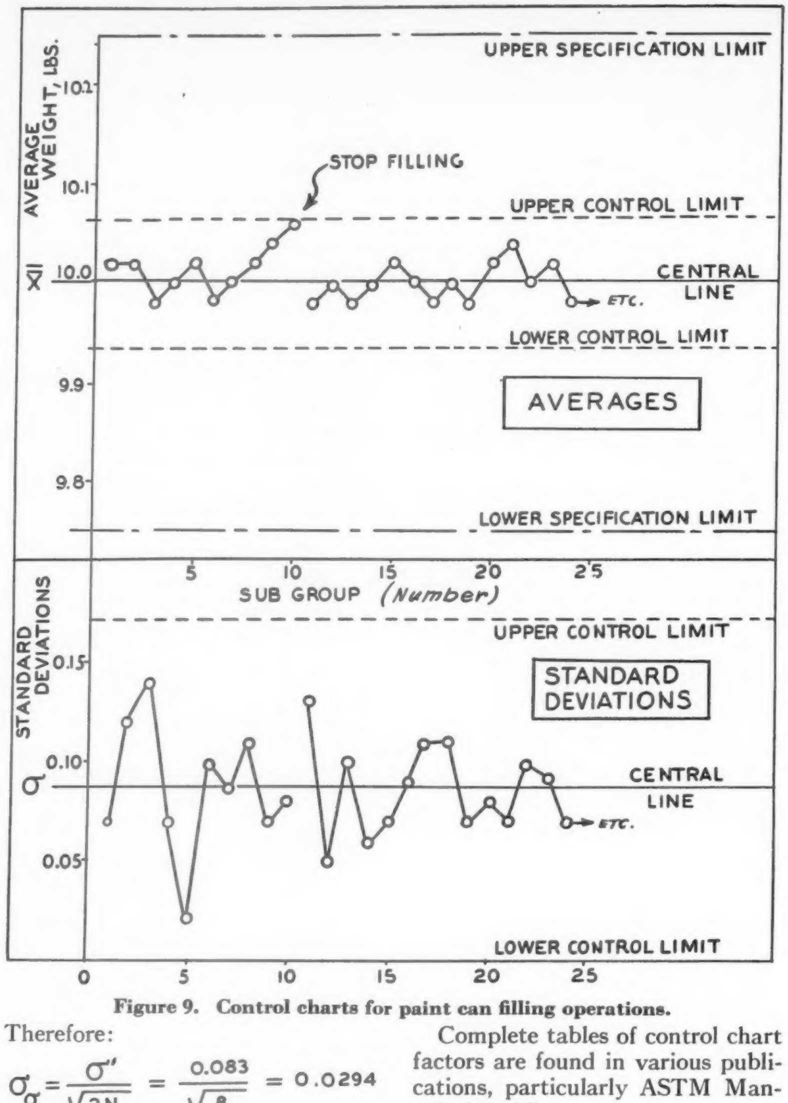

Figure 9. Control charts for paint can filling operations.

Therefore:

$$\sigma_{\sigma} = \frac{\sigma'}{\sqrt{2N}} = \frac{0.083}{\sqrt{8}} = 0.0294$$

$$3\sigma_{\sigma} = 0.088$$

The limits of the standard deviation control chart then are

$$\sigma' \pm 3\sigma_{\sigma} = 0.083 \pm 0.088 = 0 \text{ TO } 0.171$$

UPPER CONTROL LIMIT $= \sigma' + 0.088 = 0.171$

LOWER CONTROL LIMIT $= \sigma' - 0.088 = 0$

These are plotted in Figure 9.

It will be noted that the specification limits are also plotted in Figure 9. A rather large safety factor is shown in the chart. If the process capability of the filling operation is such that it cannot maintain the specified control limits then either the limits must be increased or the operation analyzed and brought back to a state of better control.

Complete tables of control chart factors are found in various publications, particularly ASTM Manuals (19, 25).

The potential value of the application of control chart techniques to such measurement as fineness of grind and wt./gal. in paint plants and Non Volatile and Viscosity, Acid Value in vehicle plants is great. The advantages to be gained in excellence of process and product control more than outway the increase of record keeping required. The technique should be used whenever practical and feasible.

Correlation in Tests

One of the greatest virtues in regression analysis and correlations is the replacement of destructive or time consuming tests by fast tests with good precision and correlation.

For example, one of the most time consuming operations in a

control laboratory is the determination of Non Volatile of resin solution and varnishes. Despite all attempts at "fast" (10 min.—30 min.) Non Volatile methods, most laboratories and specifications insist on the standard 3 hr.—105° C method—which is very precise and accurate. (54)

However, too often a batch is held up for shipment or adjustment for 3 hours—waiting for a Non Volatile. A rapid test, which would take less than 1 minute and correlate with Non Volatile is the goal of many an analytical chemist. Correlations with wt./gal. and density are somewhat insensitive.

A most promising method is the correlation of Non Volatile with Refractive Index of resin solution. This has been tried in the author's laboratory with some success. However, apparently a multiple correlation is involved between Non Volatile and Refractive Index, together with either wt./gal. of the resin solution or refractive index of solvent. Work is planned to elucidate a possible correlation.

Any such method, is bound to be invaluable in saving time and money while giving results within predictable confidence limits.

Future

The future of the use of statistical design in the paint and varnish industry is assured. As previously stated, literature references to various applications both here and abroad are appearing with increasing frequency. However, many criticisms are still being leveled at statistics in uninformed circles (53). A common fallacy is that a large mass of data is required before it can be analyzed. The statistics of small samples has been well worked out and this paper presents some of the methods applied to data which are certainly not voluminous. It must be emphasized that statistical procedures do not make a substitute for common sense, experience and other qualities of the technologist in conducting his work. They do encourage a degree of objectivity in assessing results and certainly reduce the ability of the experimenter to read into results that which he would like to believe. Statistics removed from practical events are valueless, but in combination with the technical experience of the user, they provide a strong tool.

It is admitted that the use of statistical methods in paint technology is based on a limited experience. In other fields, a body of experience is available to guide the investigator in planning and interpreting his work. With increased use of the methods and making available the experience gained in their use, the most suitable approaches will become apparent and there will be sufficient knowledge available to increase further the efficiency of these experiments.

Like many good tools, statistical methods are sharp and double-edged; the novice is in danger of cutting himself (11). Experience shows that it is all too easy to get into a rut in which investigations are designed mechanically and the results blindly accepted as true. No mechanical process can substitute for thought.

With the continual improvement of experimental designs, such as blocks and Box-Wilson techniques—and with the wider understanding of these methods that will come from closer association and study, the application of this type of thinking will pervade all technical levels of our industry.

It remains for the forward-looking technical men, production men and managers to learn where and how they can further arm themselves with these statistical tools. Here they can be helped by the many references cited in the body of this paper. Also, other review articles, bibliographies and books offer considerable information which can be digested with a little perseverence. (1, 9, 12, 22, 43, 44, 46, 50, 51) The recent series in "Industrial and Engineering Chemistry" by Dr. Youden—entitled "Statistical Design" is particularly recommended. (27-42)

Various groups, organizations and educational institutions offer special courses or conduct meetings and symposia on statistical subjects of interest. Among these are: the Gordon Research Conferences (AAAS), the Chemical Group of the American Statistical Association, the American Society for Quality Control, The American Chemical Society (local sections have held over 100 meetings on statistical subjects), North Carolina State College (Institute of Statistics), Virginia Polytechnic Institute, University of Florida, Harvard Business School, University of Oklahoma and Cornell University.

We hope that the above discussions have kindled in the reader an interest in the subject of statistical methods. The rest is up to him.

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GLOSSARY OF TERMS

X————Value or representation of a variable (Time, temperature)

Y————Value or representation of an effect (yield, gloss)

N or n————Number of observations or samples

i————Class interval

f————Frequency of observations (within a class interval)

Σ (ΣX)————Summation (Summation of X values)

$\overline{X}$————Average of N values of X

$\overline{\overline{X}}$————Grand Average—average of several $\overline{X}$'s

x, y————$X-\overline{X}$, $Y-\overline{Y}$

δ (or A.D.)—Average deviation

σ————Standard deviation

σ' (σ'_{est})————Standard deviation of the universe of values (estimate)

$\sigma_{\overline{X}}$————Standard deviation of averages for X

σ_σ————Standard deviation of the standard deviation

σ^2————Variance—Mean square

p————Probability of occurrence of an event

t————Student's t statistic

D.F.————Degrees of Freedom

χ^2————Chi square

F————F variance ratio

z————z transformation—variance ratio

ρ_r————Spearmans's rank correlation coefficient

r————Correlation coefficient

σ_{ys}————Standard error of estimate

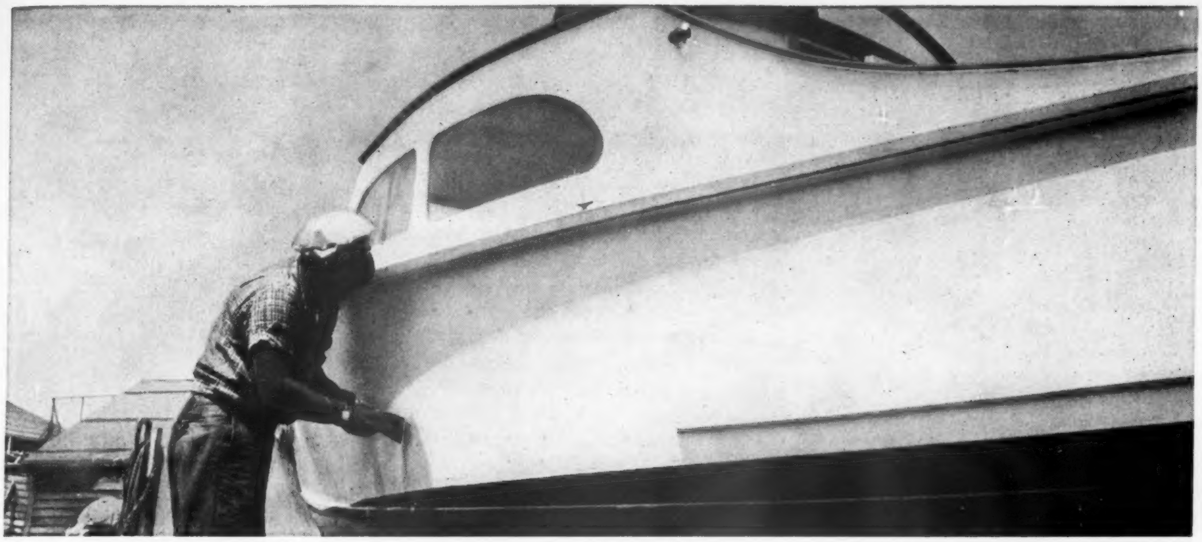
a, b————Coefficients of the regression equation

α, β————Measures of kurtosis and skewness

Q————Quartile point

$\pi_{2,\,3}$ etc.————Moment around the mean

H_o————Null Hypothesis



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NEWS

Hon. Charles P. Taft

Mayor Taft of Cincinnati To Keynote Paint Meet

Mayor Charles P. Taft of Cincinnati will present the Keynote Address at the 34 Annual Meeting of the Federation of Paint and Varnish Production Clubs Oct. 22-24 at the Netherland Hilton Hotel, Cincinnati, Ohio.

The subject of his talk has not as yet been disclosed but it is expected that he will draw from his many years of experience in national and international affairs to present a topic of timely importance.

Mr. Taft, son of William Howard Taft, the 27 President of the United States, is a native of Cincinnati. He first became associated with that city's government as the Prosecuting Attorney of Hamilton County in 1927. A keen observer of local affairs he organized the Cincinnati Regional Crime Commission and was a leading sponsor of the County Home Rule Amendment in 1933.

He was one of a group of citizens who urged the adoption of the city manager plan and the story of this change in Cincinnati's type of government was told in Mr. Taft's first published book, "City Management—The Cincinnati Experiment" in 1933. His other books include, "You and I—and Roosevelt" in 1936, "Why I Am for the Church" in 1947, and "Democracy in Politics and Economics" in 1950.

After graduating from Yale University with an LL.B Degree in 1921, he practiced law with his brother Robert, the late U. S. Senator from Ohio, in the firm of Taft and Taft. At present he is a member of the law firm of Headley, Sibbald, and Taft in Cincinnati.

Mr. Taft has been serving the Federal government for some 20 years. He has been: Chairman of the Federal Steel Mediation Board; Director of Community War Services of the Federal Security Agency; Director of Wartime Economic Affairs, Department of State; Director of Transport and Communications Policy, Department of State; member of the President's War Relief Control Board; and member of the U. S. Advisory Committee on Voluntary Foreign Aid.

In addition to being a tax and trial lawyer he is also a labor consultant and housing expert. He was an attorney for the United Auto Workers (CIO) in 1938; labor consultant for Monsanto Chemical Co. in 1946; and a U. S. government mediator in Toledo, 1934, and the Little Steel strikes in 1937.

As a churchman his contributions have been outstanding. In 1947-48 he was the President of the World Council of Churches. Today he serves that organization as the Chairman of the Information Department and the Church and Economic Life Department. Mr. Taft is a Senior Warden of Christ Episcopal Church in Cincinnati.

•

Young Executives Meet

A panel discussion covering the pros and cons of the large corporation versus the smaller independent organization in production, sales, and management was the highlight of the first meeting of the fall season held last month by the Young Executive Group of the New York Paint, Varnish and Lacquer Association.

•

U.S.I. 50th Anniversary

Fifty years of industrial alcohol and chemical production is being celebrated Oct. 17 by U. S. Industrial Chemicals Co., Division of Nationoal Distillers Products Corp., New York City.

Maurice Van Loo

Van Loo to Give Mattiello Lecture

The Annual Joseph J. Mattiello Memorial Lecture, high point of the Annual Meeting of the Federation of Paint and Varnish Production Clubs, will be presented this year by Maurice Van Loo, director of paint research for The Sherwin-Williams Co.

The lecture commemorates the name of Joseph J. Mattiello, who, as a member of the Federation did much to expand the application of science in the protective coatings field.

Mr. Van Loo is the author and co-author of numerous publications in the field of physical and colloid chemistry and testing of paints and in corrosion. His work emphasizes research in critical pigment volume concentration aspects of paints, rheology of paint systems and in a specialized form of metal corrosion called "filiform corrosion."

He has been with Sherwin-Williams since 1927 when he began as a research chemist at the Cleveland plant. In 1933 he was transferred to the Chicago plant where he was superintendent of the Chicago technical service department until 1935. He was then made assistant director, Allied Research Laboratories, which were formed in 1935 by The Sherwin-Williams Co. and affiliates with Dr. C. D. Holley as director.

The title of the 8th Mattiello Lecture is "Physical Chemistry of Paint Coatings—A Constant Search."

NEWS

Mildew Discoloration Discussed by Milton Goll

"Fundamental Aspects of Mildew Discoloration of Paint" was

Milton Goll

the subject of a talk presented by Milton Goll, of Milton Goll Associates, Livingston, N. J., at the first fall meeting of the New York Paint and Varnish Production Club held last month.

Mr. Goll, who has done extensive research in industrial microbiology specializing in the deterioration of paints, adhesives, plastics, textiles, wood, etc., discussed the factors that predispose a paint film to mildew attack.

Among those factors discussed were the choice of vehicles, pigments, and extenders, and the balance of these ingredients achieved in the overall formulation. Conclusions based on the examination of oil based, alkyd, oleoresinous, PVaC, acrylic, and styrene-butadiene paints were presented.

Form Amoco Chemicals In 3-Company Consolidation

Amoco Chemicals Corp. will be the name of a company resulting from the proposed consolidation of three chemical subsidiaries of Standard Oil Company (Indiana), it was announced by Frank O. Prior, president of Standard.

Jay H. Forrester will become president of the new corporation when consolidation of the companies is completed late this year.

The first step in the reorganization has been taken with the renaming of the Hidalgo Chemical Co. to the new name Amoco Chemicals Corp. The subsidiaries being consolidated are Indoil Chemical Co., Chicago; Pan American Chemicals Corp., New York City, and Amoco Chemicals Corp., formerly Hidalgo Chemical Co., Tulsa, Okla. Headquarters after the consolidation will be at Chicago.

Color Forum Features of Federation Meeting

Leading authorities in the industry will be on the Color Measurement Forum to be presented on the last day of the 34 Annual Meeting of the Federation of Paint and Varnish Production Clubs. The meeting will be held Oct. 22-24 at the Netherland Hilton Hotel in Cincinnati.

F. S. Grundy
Moderator

Dr. I. Balinkin

M. P. Morse

H. A. Tuttle

W. C. Parle

A. J. Bruning

N. R. Pugh

Moderating the Forum and presenting the "Introduction" will be Frank S. Grundy, of Imperial Flo-glaze Paints, Ltd.

Following are the members of the Forum and their subjects:

Basic Elements in Color Measurement, Dr. Isay Balinkin, University of Cincinnati.

Color Measurement With the General Electric Spectrophotometer, Mark P. Morse, E. I. duPont de Nemours & Co., Inc.

Use of Gardner Color Difference Meter for Production Control of Shading Operations, Sam J. Huey, The Sherwin-Williams Co.

An Application of the 'Colormaster' Differential Colorimeter for Control and Evaluation of Maintenance Paints, Henry A. Tuttle and Melvin M. Gerson, Ford Motor Co.

Color Measurement With the I.-D.L. Color Eye, William C. Parle, California Ink Co.

Visual Control of Color (The Davis-Bruning Colorimeter), A. J. Bruning, H. B. Davis Co.

An Application of the Beckman Model D Spectrophotometer to Paint Color Control, Norman R. Pugh, Sears, Roebuck & Co.

Lower formulating costs with BAKELITE Epoxy Resin Solution EKSA 2002

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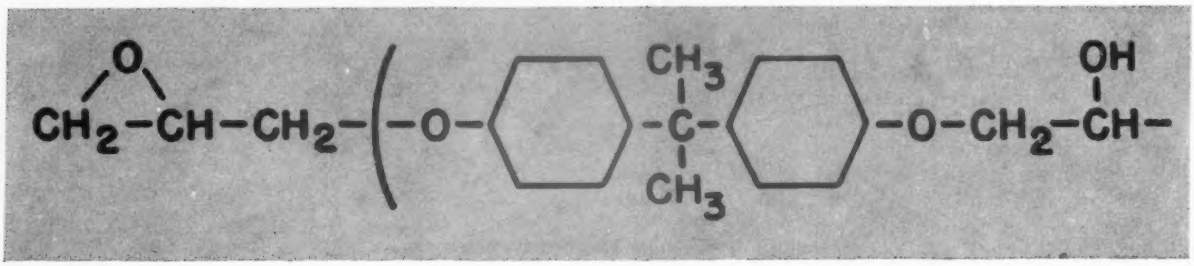


EKSA 2002 is a resin solution (75% solution in toluene) of crystal-clear BAKELITE Epoxy Resin EKRB 2002. Solution preparation by the user is entirely eliminated, as well as any difficulties of sintering. A wide range of formulating possibilities is afforded simply by mixing in additional components. This makes possible the preparation, for example, of a 50% solids solution, containing ⅓ toluene and ⅔ of any other compatible solvent desired. Ease of formulation and savings in cost naturally result.

Table 1 gives the typical properties of the resin solution. Properly formulated coatings based on EKRB 2002, or the solution EKSA 2002, exhibit excellent durability, toughness, chemical resistance, flexibility and adhesion. They show better compatibility and solubility, an important factor in industrial coatings. They can be used in the coating of flexible substrates such as paper, foils and certain plastic film, as well as for pipe coatings, collapsible tube finishes, electrical insulation varnishes, appliance finishes, and superior masonry and concrete paints.

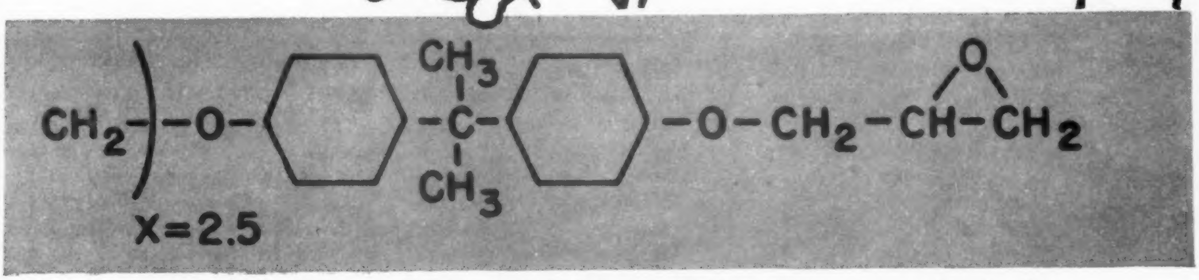
Two Other BAKELITE Epoxy Resins

BAKELITE Epoxy Resins EKRA 2053 and EKRD 2003 are higher in molecular weight and have higher melting points than EKRB 2002. They are designed primarily for esterification. Both are solid lumps of pale-amber resins. EKRD 2002 is exactly similar to EKRA 2053 except that in short-oil varnishes it yields vehicles of higher viscosity for the same solids content and cooking time. Coatings exhibit the same qualities as those based on EKRB 2002, and are designed for the same surfaces and purposes.

TABLE 1
TYPICAL PROPERTIES

	RESIN EKRB 2002	RESIN SOLUTION EKSA 2002 (75% solution in toluene of EKRB 2002)
Softening Point, of (Ball and Ring)	145-170	
Epoxide Equivalent	450-525	600-700
Ash Content, %	0.03 maximum	0.03 maximum
Viscosity	C-G* (Gardner-Holdt)	3500-5000cst
Color (Gardner 1933)	6 maximum*	6 maximum
Specific Gravity	1.17	1.09
Esterification Equivalent	145 approx**	
Clarity	Crystal Clear	Crystal Clear
Non-volatile, %	100	73-77

*40% non-volatile in butyl CARBITOL solvent
**This value is necessarily approximate because of slight variations in epoxide equivalent



STRUCTURAL FORMULA—"BAKELITE" EPOXY RESIN EKRB 2002—The average number of units in the bracket is 2.5. As can be seen, the molecule offers many reaction possibilities. The curing agent reacts to polymerize and cross-link the resin.

Call a Bakelite Company technical representative for complete information and assistance in putting this new Epoxy Resin Solution to work for you. Or write for our Technical Releases Nos. 15 & 16, which describe all these Epoxies in greater detail, together with suggested formulations. Address Dept. UJ-153.

It pays to formulate with

BAKELITE
BRAND
RESINS for COATINGS

BAKELITE Vinyl, Polyethylene, Phenolic, and Epoxy Resins and Styrene and Vinyl Acetate Latexes for Coatings.

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

NEWS

Howard Scholl

H. Sholl, of C. M. Athey, Wins First Shuger Medal

Howard Sholl, of C. M. Athey Paint Co., has been awarded the first "Herman H. Shuger Memorial Medal," established this year by the Baltimore Paint and Varnish Production Club to honor Mr. Shuger's memory.

Presentation of the medal will take place at a joint meeting Oct. 12 of the Baltimore Paint and Varnish Production Club and the Baltimore Paint, Varnish and Lacquer Association at the Park Plaza Hotel, Baltimore.

Mr. Shuger was a charter member and was instrumental in organizing the Baltimore Club. He was one of only two people who served as club president for two terms. His activity in the club continued from its inception, in 1932, until his death in 1954. He was also active in the Baltimore Paint, Varnish and Lacquer Association and was its president for the year 1946-47.

Mr. Sholl is the first member of the Baltimore Club to become an officer in the Federation of Paint, Varnish Production Clubs. He was active in technical committees and presented a paper at the Federation annual meeting in 1950. He is a past president of the Baltimore Club, and was a member of the board of directors of the Federatoin.

Interesting Papers to Be Read at Federation Meet

Among the important papers to be delivered at the 34 Annual Meeting of the Federation of Paint and Varnish Production Clubs Oct. 22-24 at the Netherland Hilton Hotel, Cincinnati, are the following:

An Evaluation of Anti-Skinning Agents in Clear Vehicles, Philadelphia Club. To be presented by P. J. Whiteway, Jr., chairman of the Technical Committee.

A Method of Determining Brushability by Instrumentation, New England Club. To be presented by Edward Berberian, Chairman of the Technical Committee.

E. G. Shur

P. J. Whiteway

Edward Berberian

H. J. Kasch

The Comparative Evaporation Rates of Paint Solvents: II, New York Club. To be presented by E. G. Shur, chairman of Technical Subcommittee 66.

Blackening Effect of Hydrogen Sulphide on Exterior White House Paints, Pittsburgh Club. To be presented by Herman J. Kasch. (Gerald B. Ward, Chairman of the Technical Subcommittee.

Carbide to Increase Cellosize H-E-C Production

Construction of a major unit at Niagara Falls for the production of Cellosize hydroxyethyl cellulose has been announced by D. B. Benedict, president of Carbide and Carbon Chemicals Co., a Division of Union Carbide and Carbon Corp.

Completion of this unit, scheduled for the fall of 1957, will substantially increase Carbide's production capacity for Cellosize H-E-C. This expansion embodies the latest improvements for the production of the powdered water-soluble Cellosize H-E-C which have been developed in the smaller production unit now operating at Niagara Falls.

W. C. Heidenreich is superintendent of the Niagara Falls plant and Rudolph Paluzelle, production unit head, will be in charge of the new unit.

Cellosize H-E-C is an important raw material in the paint, adhesive, paper, and other industries. It has major uses in water-base paints. In the manufacture of the base latex, Cellosize H-E-C keeps the various ingredients suspended and dispersed and a new grade of Cellosize H-E-C, gives body to the finished paint.

Corrosion Engineers to Meet Nov. 15-16 in on Coast

"New Developments in Corrosion Control" is the general subject the Western Regional Division Conference of the National Association of Corrosion Engineers to be held Nov. 15-16 at the Lafayette Hotel in Long Beach, Cal.

Included in the general subject will be refinery and pipe line corrosion problems as well as information on new materials and methods.

Prior to the conference a Short Course, "Practical Considerations of Underground Corrosion for Nontechnical Personnel," will be presented by the University of California Extension Division with the cooperation of the N.A.C.E. Western Regional Division. It will be given at the Lafayette Hotel Nov. 13-14.

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Plant Maintenance Show

"Good Maintenance or Bad—The Difference Is Profit" has been selected as the 1957 theme of the Plant Maintenance & Engineering Show, it was announced by Clapp & Poliak, the exposition management.

The show, and the concurrent conference, both in their eighth year, will be held Jan. 28-31 in Cleveland's Public Auditorium.

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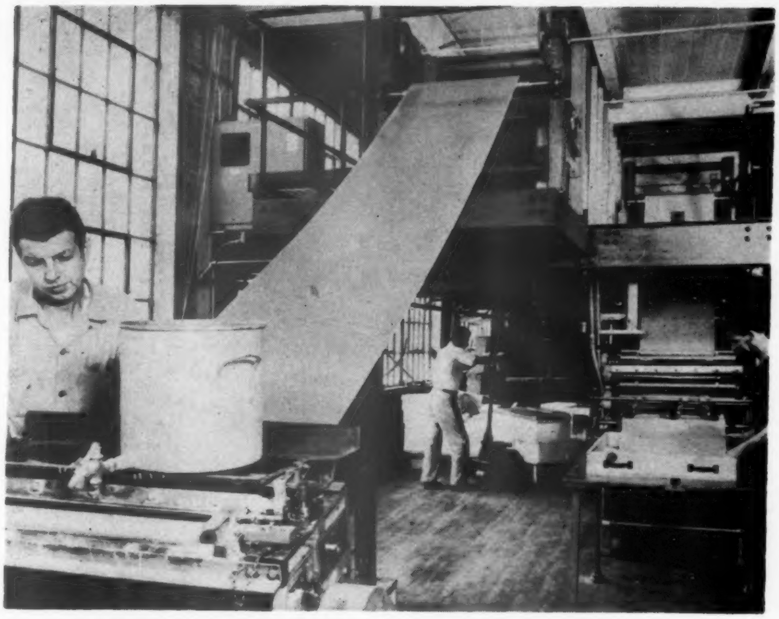
NEWS

Irving Fein Elected A Vice Pres. of U. S. Hoffman

The election of Irving Fein as a vice president of the United States Hoffman Machinery Corp. has been announced by Hyman Marcus, chairman and president. Mr. Fein, a director of U.S. Hoffman, is president of the Fein group of can manufacturing companies acquired by U. S. Hoffman last year. He is executive head of the company's can and container division, which consists of the Standard Can Corp., Pittsburgh; Commercial Can Corp., Newark, N. J., and the Atlas Can Corp. and Fein's Tin Can Co., Brooklyn. U. S. Hoffman manufactures cleaning and pressing equipment and various types of industrial equipment and machinery.

Irving Fein



IMPROVES PAINT CHIP QUALITY: **A newly designed color-coater recently put into use at the Cincinnati plant of Strobridge Lithographing Co. is said to have made possible remarkable improvements in paint chip quality while permitting increased production and speeding delivery. Unlike the older type color-coaters, this new model operates on a reverse principle, with the roller moving in a direction opposite to the movement of the paper. This permits the application of a smooth, even film of paint of any pre-metered thickness. It prevents paint striations thereby eliminating patterns in the coated surface. Color chips produced by this new process are claimed absolutely pattern-free. Speedy drying is the color-coater's other claimed feature.**

Ciba Sales Agents

Ciba Company Inc., Kimberton, Pa., has announced the following agents to handle its "Araldite" epoxy resins: Harry A. Baumstark & Co., St. Louis, Mo.; Charles L. Burks Co., Black Mountain, N.C.; John D. Butts, Pittsburgh, Pa.; Commercial Chemicals, Inc., Buffalo, N.Y.; Delmonte Plastics Inc., Los Angeles, Cal.; Henry L. Grund, Inc., Cleveland, Ohio; Fred A. Jensen & Associates, Chicago, Ill.; T. C. Kiesel, Cincinnati, Ohio; The A. B. Kohl Sales Co., Baltimore, Md.; D. H. Litter Co., New York, N.Y.; Matteson-Van Wey, Detroit, Mich.; Geo. A. Rowley & Co., Inc., Philadelphia, Pa.; Thompson-Hayward Chemical Co., Kansas City, Mo.

Lead Industries Ass'n Moves

The Lead Industries Association has moved to 60 E. 42 St., New York 17, N. Y. The telephone number is MUrray Hill 2-2633.

Barrett Div. Announces Fellowship Winners

Barrett Division, Allied Chemical & Dye Corp. has announced that the following graduate students were selected by their respective universities to receive the Allied Chemical & Dye Corporation Fellowships offered by Barrett Division for the academic year 1956-57:

Alex Thomas Rowland, candidate for Ph.D. degree at Brown University; August Harold Maki, candidate for Ph.D. degree at the University of California in Berkeley; Bernard F. Cinadr, candidate for Ph.D. degree at Case Institute of Technology; George Alvin Wiley, candidate for Ph.D. degree at Cornell University.

Also John Kinsey Gillham, candidate for Ph.D. degree at McGill University; Floyd Norton Daugherty, candidate for Ph.D. degree at the Pennsylvania State University; James William Mullen, candidate for Ph.D. degree at Rensselaer Polytechnic Institute, and Lewis Reinder Honnen, candidate for Ph.D. degree at the University of Washington.

Zinc Institute Moves

The American Zinc Institute, Inc., has moved to new and larger offices in Suite 2020 of the Lincoln Building, 60 E. 42 St., New York 17, N. Y. The phone number remains unchanged.

Nat. Chemical Buys Liebich

National Chemical and Mfg. Co., Chicago, makers of Luminall brand paints, paint and varnish removers and paint specialties, has purchased the 40-year old G. J. Liebich Co., Chicago, manufacturers of paints, varnishes, wood stains and enamels.

The Liebich Co. will be operated as a division of National Chemical. V. C. McGuire, formerly territorial sales manager for National Chemical in Kansas and Iowa, has been named sales manager.

Nat. Aniline Akron Branch

National Aniline Division, Allied Chemical & Dye Corp., recently opened a branch office at 326 S. Main St., Akron, Ohio, according to an announcement by H. J. Daigneault, vice president.

The office is in the charge of R. W. Vail. Its telephone number is Blackstone 3-9324.

Officers
Federation of Paint & Varnish Production Clubs
34th Annual Meeting

M. A. GLASER
President-Elect

C. L. SMITH
President

H. G. SCHOLL
Treasurer

Federation of Paint and Varnish Production Clubs
YE OLDE PAINT STONE
1737

C. HOMER FLYNN
Executive Secretary

PROGRAM

34th FEDERATION ANNUAL MEETING

SUNDAY, OCTOBER 21

1:15 P.M. Federation Council Meeting

MONDAY, OCTOBER 22

10:00 A.M. Meeting opens in Pavillon Caprice
Invocation—Verne C. Bidlack
Greetings—Clyde L. Smith, President of the Federation

10:20 A.M. "Extender Pigments in Blister Resistant House Paints"—Northwestern Club.

10:40 A.M. "Deterioration of Protective Coatings Due to Molds and Bacteria (Bibliographic Study)"—Chicago Club.

11:00 A.M. Report of the Federation Corrosion Committee —Dr. Joseph W. Tomecko, Chairman.

11:15 A.M. "Some Practical Applications of a Wide Range Thin Film Recording Viscometer"—Oil and Colour Chemists Assoc. (England).

11:35 A.M. Keynote Address—The Hon. Charles P. Taft, Mayor of the City of Cincinnati

2:00 P.M. "Studies in Fire Retardant Paints: III (Chlorinated Alkyd Paint Systems"—Baltimore Club.

2:20 P.M. Address by Joseph F. Battley, President of the National Paint, Varnish and Lacquer Association.

2:40 P.M. The Annual Joseph J. Mattiello Memorial Lecture—Maurice Van Loo.

3:40 P.M. "The Comparative Evaporation Rates of Paint Solvents: II"—New York Club.

4:00 P.M. "Polyvinyl Acetate Emulsions for Outdoor Paints"—FATIPEC.

4:20 P.M. "The Search for a Incompatibility Test"—Cleveland Club.

TUESDAY, OCTOBER 23

9:00 A.M. "The Effect of Light of Different Wave Lengths on the Degradation of Clear Coatings"—Pacific Northwest Club.

9:20 A.M. "A Method of Determining Brushability by Instrumentation"—New England Club.

9:40 A.M. "Exposure Characteristics of Clear Finishes for Exterior Wood Surfaces"—Golden Gate Club.

10:00 A.M. Panel Discussion—"Chemical Resistant Coatings"

11:00 A.M. "An Evaluation of Anti-Skinning Agents in Clear Vehicles"—Philadelphia Club.

11:20 A.M. "Factors Affecting Freeze-Thaw Stability of Latex Paints"—Louisville Club.

11:40 A.M. "Blackening Effect of Hydrogen Sulphide on Exterior White House Paints"—Pittsburgh Club.

WEDNESDAY, OCTOBER 24

9:00 A.M. Panel Discussion—"Production"

10:00 A.M. Color Measurement Forum

10:05 A.M. "Basic Elements in Color Measurement"—Dr. Isay Balinkin, University of Cincinnati

10:50 A.M. Forum on Practical Applications of Colorimetry in Development and Control of Organic Finishes

12:20 P.M. Open discussion of papers

2:00 P.M. "Adhesion and Adhesives"—Dr. James S Long, of the University of Louisville

2:30 P.M. Panel Discussion—"Blister Proof Paints"

3:30 P.M. Annual Business Meeting of the Federation
Report of Election and Announcements

Social Events

Tuesday, Oct. 23, 7:00 P.M.
Banquet, Entertainment and Dance

REGISTRATION

Sun.	*Oct. 21*	*1:00 P. M. - 5:00 P. M.*
Mon.	*Oct. 22*	*8:30 A. M. - 6:00 P. M.*
Tue.	*Oct. 23*	*8:30 A. M. - 5:00 P. M.*
Wed.	*Oct. 24*	*8:30 A. M. - 4:00 P. M.*

EXHIBITORS AT 21st PAINT INDUSTRIES' SHOW

A

PAUL O. ABBE, INC. 434
Little Falls, N. J.
Ball and Pebble Mills and Mixers
Garlick Ringen Kleinfeldt Philo

ADVANCE SOLVENTS & CHEMICAL 306-307
Div. Carlisle Chemical Works, Inc.
New Brunswick, N. J.
Zirco-Rare Earth and Chemical Specialty Additives
Mullaly Gregg Herrmann DaSilva
Tucker
— See Advertisement Front Cover —

C. M. AMBROSE CO. 406
Seattle, Wash.
Self-Cleaning Strainer, Fillers
Ambrose Dunn Smith Styba

ANDERSON-PRICHARD OIL CORP. 334
Chicago 13, Ill.
Solvents, Naphthas, Thinners, Diluents, Asphalts, Pitch
Dresser Easterday Phillips Lawson
Fessler Walterscheid Gault Centracco
Benes Rubek Johnson

ARCHER-DANIELS-MIDLAND CO. 343-344
Minneapolis, Minn.
Vehicles, Resins
Representatives from all departments.

ATLAS ELECTRIC DEVICES CO. 408
Chicago 13, Ill.
Accelerated Weathering Equipment
Norton Alport Lane
— See Advertisement Page 138 —

B

BAKELITE CO. 331-333
New York, N. Y.
Vinyl Acetate Latex, Epoxy Resins, Primers for Vinyl Coatings, Cold-blend Phenolic Enamels
Norum Bertics Fetterman Callas
Larson Fix Joiner Given
Schwahn Brenneck Carpenter Maines
— See Advertisements Pages 86, 87, 104, 105 —

BAKER CASTOR OIL CO. 305
New York, N. Y.
Additives, Drying Oils, Lacquer Plasticizers
Orling Hayes Jubanowsky Patton
Swenson Ottens
— See Advertisement Page 118 —

BARRETT DIV. 303-304
Allied Chemical & Dye Corp.
New York, N. Y.
Phthalic Anhydride, Plasticizers, "Cumar" Resins, Plaskon Resin Line
Barry Boardman Cislo Davis
Delaney Ellis Garvey Ginsler
Hinebauck Hoppers Ironside Kerr
Pitcher Pruitt Safranski Stumpe
Warmouth Yanason
— See Advertisement Page 113 —

BENNETT INDUSTRIES, INC. 337
Peotone, Ill.
Steel Pails, Steel Drums
Bennett LePan Ernst Sorensen

BORDEN CO. 440
Chemical Div.
New York, N. Y.
Paint Latices for Exterior and Interior Use
Sullivan Lodge Meyers Pratt
Gordon

BRIGHTON CORP. 449
Cincinnati, Ohio
Alkyd Resin Kettles, Varnish Cooking Equipment
Hock Schneider Steioff

BUCKMAN LABORATORIES, INC. 301
Memphis 8, Tenn.
Preservatives
Buckman Stitt Deitzel Weiss
Kopitke

BURT MACHINE CO. 404-405
Baltimore 1, Md.
Labelling Machine
Miller Whitehurst Kruse Reiland
Groudel Scheafer

C

GODFREY L. CABOT, INC. 429-430
Boston, Mass.
Pigments, Carbon Blacks, Cab-O-Sil, Wollastonite
Duffy Marsh Carpenter King
Berstein Roemelt Burbine Clark
Magno Bullock McNeil Parson

CAMBRIDGE INDUSTRIES CO., INC. 448
Cambridge, Mass.
Resoflex Plasticizers for Polyvinyl Acetate
Pockel Stone

CARBIDE AND CARBON CHEMICALS CO. 350-351
Div. of Union Carbide & Carbon Corp.
New York 17, N. Y.
Coalescing aids for PVAc paints, Chemicals for Resin Emulsions, Solvents, Plasticizers, Thickener for Latex Paints
Technical Representatives and Specialists
— See Advertisement Page 13 —

CARBOLA CHEMICAL CO., INC. 415
Natural Bridge, N. Y.
Extender Pigments
Koenig Rogers Smart Spriggs
Wagoner
— See Advertisement Page 166 —

CARBON DISPERSIONS, INC. 414
Newark, N. J.
Black Dispersions, Anti-Floating Tinting Dispersion, Color Dispersions
Brauch Keegan Wilmer Dimlich
— See Advertisement Page 137 —

CARGILL, INC. 335
Minneapolis, Minn.
Linseed Oils, Soybean Oils, Fish Oils, Alkyd Resins, Specialty Products
Baldwin Crocker Gutkin Kamen
Kantor Klobe Knott Rogaliner
Weisman Yarger
— See Advertisement Page 30 —

CATALYTIC COMBUSTION CORP. 436
Detroit 8, Mich.
Oxidizing Catalysts, Fume Elimination and Heat Recovery Systems
Storer Bryant Byrnside Goodell

CELANESE CORP. OF AMERICA 341-342
Chemical Div.
New York 16, N. Y.
Flame-Retardant Plasticizers, Special Solvents, Aldol Products
Kampschulte Werner Baker Mamola
Schwab Swanezy Carroll Aichler
Cornwell Hecht Smith Polacek
Gerry Curry Wyart Weich
Hoyt
— See Advertisement Page 109 —

CELANESE CORP. OF AMERICA 446-447
Plastics Div.
Newark, N. J.
Polyvinyl Acetate in primers, sealers, exterior, interior and specialty finishes. Formulation of homopolymer and copolymer emulsions
Representatives from research and technical service laboratories
— See Advertisement Pages 24, 25 —

RAYBO CHEMICAL CO. 426
Huntington, West Virginia
Paint Additives
Technical Representatives
(Replaces Chisholm Ryder Co. of Pa.)

COLTON CHEMICAL CO. 435
Div. of Air Reduction Co., Inc.
Cleveland, Ohio
Vinyl Acetate Emulsions
Krashin, Jaffe, Ostrow, Hill
Rankin, Werner, Fickenscher, Ames
Stettler, Kaine, Mather
— See Advertisement Page 146 —

COLUMBIAN CARBON CO. 313
New York 17, N. Y.
Mapico Colors, Carbon Blacks, Carbon Black Dispersions
Keating, Foster, Wade, Kealy
Gotshall, Stiff, Ford, Kocik
Cools, Downs
— See Advertisement Page 9 —

COMMERCIAL SOLVENTS CORP. 419-420
New York 16, N. Y.
Nitroparaffins as solvents, emulsifying agents
Wansik, McCarthy, Broderick, Farley
Maple, Cooke, Luedeke, McInnes
— See Advertisement Page 18 —

CUNO ENGINEERING CORP. 411
Meriden, Conn.
Filters and Straining Devices
Whorf, Grupe, Belger, George
Carlson, Yule
— See Advertisement Page 170 —

D

J. H. DAY CO. 433
Cincinnati, Ohio
Laboratory Mill, Pilot Plant Mill, Pony Mixers
Diltz, Russell, Bruestle, Wershay
— See Advertisement Page 132 —

DEWEY & ALMY CHEMICAL CO. 348
Div. W. R. Grace & Co.
Cambridge, Mass.
Vinyl Acetate Polymer and Copolymer Emulsions
Bare, Brookes, Tompkins, Zirpolo
Broughton, Morton, Haden, Kaalstad
Witzel, Neunhoffer, Larson, Partrick
Brown

DOW CHEMICAL CO. 318-319
Midland, Mich.
Latex for Interior Exterior Paint and Industrial Finishes
Morand, Haskell, Johnson, Gow
Dorman, Donalds, Parker
— See Advertisement Page 27 —

E. I. DU PONT de NEMOURS & CO. 450
Electrochemicals Dept.
Wilmington, Del.
Polyvinyl Acetate Emulsion
Sawyer, Argana, Beardsley, Byrum
Czerwin, Feemster
— See Advertisement Pages 19, 89 —

E

EASTMAN CHEMICAL PRODUCTS, INC. 346-347
Kingsport, Tenn.
Plasticizers, Solvents, Half-Second Butyrate Cellulose Ester Film Formers
Rutherford, Cox, Ball, Crowley
Moore, Gearhart, Langston, Abernathy
Reebel
— See Advertisement Page 15 —

EPWORTH MFG. CO. 403
Detroit 10, Mich.
Ball Mills, Lined Mills, Mixers, Agitators, High Shear Mixers
Jeanne, Zink, Leith

F

FARNOW, INC. 456
Long Island City, N. Y.
Flat Alkyd Resin, Wrinkle Finish Based on FV 762, Emulsion and Water Base Paints featuring C-12 Resin
B. Farber, Bauman, Freund, Kristeller
S. Farber, Shandler, Saputo
— See Advertisement Page 126 —

FIRESTONE PLASTICS CO. 438
Pottstown, Pa.
Exon Vinyl Resins
Boyer, Corbin, Henry, Thompson
— See Advertisement Pages 100, 101 —

G

GENERAL ELECTRIC CO. 336
Schenectady, N. Y.
Methylon Resin, Silicone Products
Dugan, Cahn, Daniels, Burnett
Aldrich, Brier, Bulgozdy, Cook
Frisch, Koepler, Lauroesch, Young
Blegen

GOODYEAR TIRE & RUBBER CO. 325-327
Akron 16, Ohio
Pliolite S-5 Synthetic Rubber Resin, Pliolite Latex 165
Thies, McNeer, Warner, Hussey
Neese, Bear, Gerrow, Wallace
Draman, Kann, Kelly, Platner
Houlette
— See Advertisement Page 4 —

H

HARSHAW CHEMICAL CO. 328-329
Cleveland, Ohio
Driers, Stearates, Yellow and Red Cadmium Lithopones, Organic Pigments, Aurasperse Color Dispersions
Close, Confer, Connell, Dickenson
Foote, Giordano, Harris, Hintz
Juredine, Molinari, Nice, Rock
Straka, Unkefer, Waters, Weir
— See Advertisement Page 127 —

HERCULES POWDER CO. 316-317
Wilmington, Del.
Chlorinated Rubber-Oil Dispersions, Tall Oil Fatty Acids, Pentaerythritol
Representatives from all Departments
— See Advertisement Page 173 —

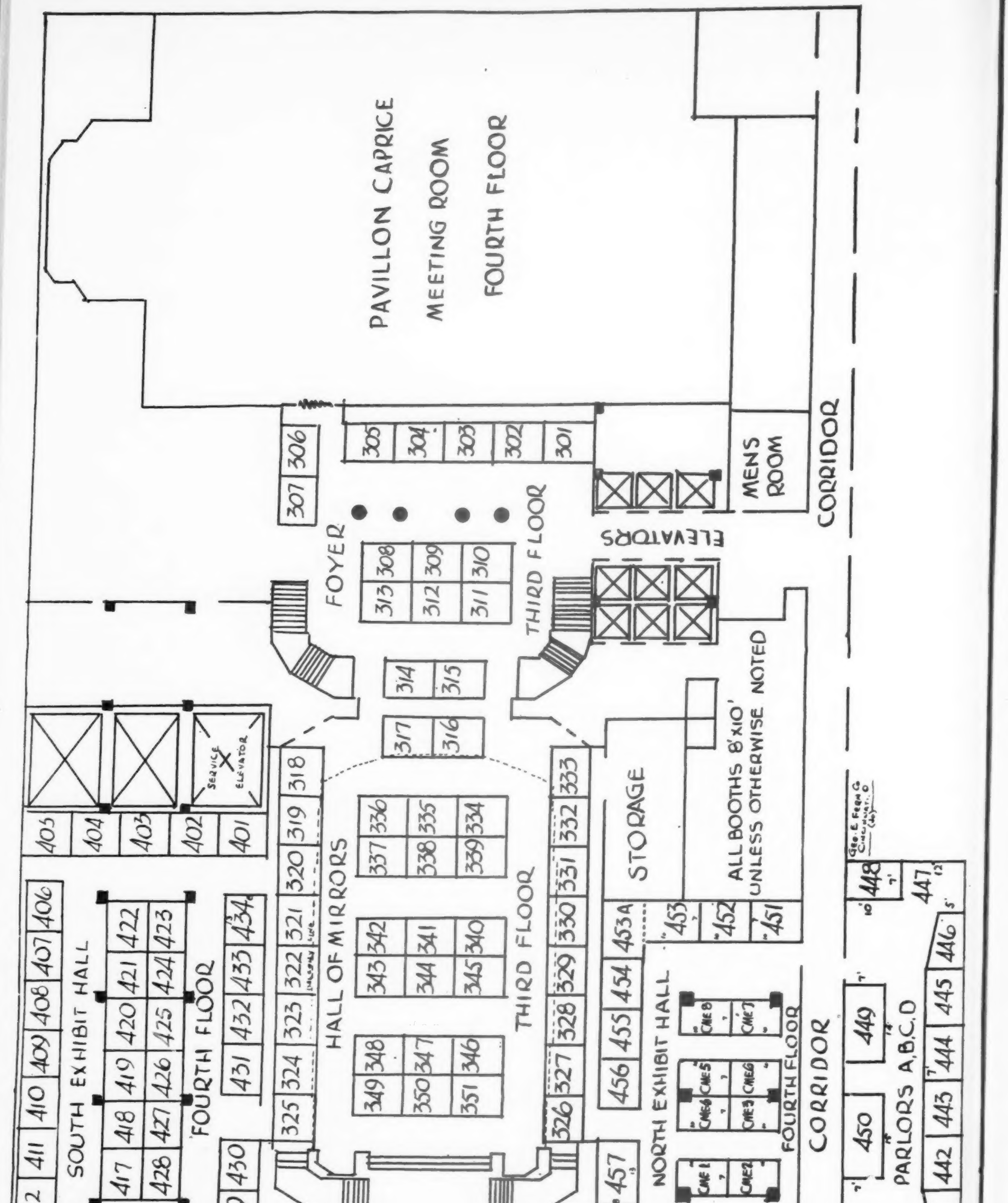
HEYDEN CHEMICAL CORP. 345
New York, N. Y.
Pentaerythritol, Trimethylolethane
Risch, Degener, Aalto, Barkley
Doroskin, Klein, Kraft, Askin
— See Advertisement Page 144 —

HERMAN HOCKMEYER CO. 428
New York 59, N. Y.
Mixing and Dispersion Equipment
Hockmeyer, Klein
— See Advertisement Page 157 —

HILTON-DAVIS CHEMICAL CO. 4th Floor Foyer
Div. Sterling Drug, Inc.
Cincinnati, Ohio
Flushing Machine, Panels of Colors both Masstone and Tint, House and Garden Colors in Panel Form
Langner, Moore, Gurska, Burks
Fitzgerald, Bendheim, Hurlbrink, Withington
Sheahan, Stephany, Baker, Fletcher
Ulmer, Ackerman

K

SPENCER KELLOGG AND SONS, INC. 320-321
Buffalo, N. Y.
Linseed Oil, Soya Oil, Castor Oil, Chemically-Modified Oils and Copolymers
Healy, Beyer, Nagel, McCready
Engel, Rowswell, Kohl, Farrington
Bienemani, Bristol, Farstad
— See Advertisement Page 141 —


PAVILLON CAPRICE
MEETING ROOM
FOURTH FLOOR
FOYER
THIRD FLOOR
ELEVATORS
MENS ROOM
CORRIDOR
SERVICE ELEVATOR
HALL OF MIRRORS
THIRD FLOOR
STORAGE
ALL BOOTHS 8'x10' UNLESS OTHERWISE NOTED
SOUTH EXHIBIT HALL
FOURTH FLOOR
NORTH EXHIBIT HALL
FOURTH FLOOR
CORRIDOR
PARLORS A,B,C,D
PASSAGE

KENT MACHINE WORKS, INC. 497
Brooklyn, N. Y.
Mixing and Grinding Machinery
Peters Weitzner Veder
— **See Advertisement Page 117** —

KINETIC DISPERSION CORP. 422-423
Buffalo, N. Y.
Kady Mill, Kady-Steelshaw Planetary Ball Mill
Kew Behrns Hiller Wheeler

L

J. M. LEHMANN CO., INC. 416
Lyndhurst, N. J.
Roller Mills, Sieving and Screening Machines, Mixers
Hoffman Mierswa Page Dittmann
Muller
— **See Advertisement Page 72** —

M

METALS DISINTEGRATING CO., INC. 424
Elizabeth, N. J.
Aluminum Paste, Aluminum Flakes, Gold Bronze Pigments
Collins McKinley Town Shaeffer

MINERAL PIGMENTS CORP. 330
Muirkirk, Md.
Synthetic Oxides, Earth Colors, Chemical Colors including "Jet Milled" and Rust Inhibitive Pigments
Representatives from all Departments

MINERALS & CHEMICALS CORP. OF AMERICA 340
Menlo Park, N. J.
Edgar ASP Products, Attapulgite Products
Hubbel Dilley J. Wheeler Smith
Wilcox P. Wheeler Wilkerson
— **See Advertisement Page 133** —

MONSANTO CHEMICAL CO. 323-324
Plastics Div.
Springfield, Mass.
Surface Coating Resins, Styrene Latices, Polyelectrolytes for Thickening Aqueous Systems
Jones Watt Parker Gordon
Hahn Kocher Goodacre Francis
MacPherson Green Schmidt Cochran
Traverso Werner Dow
— **See Advertisement Page 28, 29** —

MOREHOUSE-COWLES, INC. 412-413
Los Angeles 65, Calif.
Mills and Dissolvers
Horst Missbach Purcell Klein
Meyer

N

NAFTONE, INC. 322
New York 22, N. Y.
Oronite Naphthenate Driers, Clearate LV and WD, Nildew OL, OC, NA, AC, Nilskin, Nilskin #2, Unapex, LPR-1
Applegate Klebsattel McTavey Martin
Smith
— **See Advertisement Page 116** —

NEVILLE CHEMICAL CO. 431-432
Pittsburgh 25, Pa.
Anti-skinning Resin, Coumarone-Indene Resins, Heat Reactive and Petroleum Hydrocarbon Resins, Petroleum and Coal Tar Solvents, Hi-Flash Naphtha
Dauler Evans Craig Freeman
Wald Lauderbaugh James Villing
Cloake Marsh Zahn Isenberg
— **See Advertisement Page 128** —

NOPCO CHEMICAL CO. 302
Harrison, N. J.
Defoamers, Thickeners, Emulsifiers, Pigment Dispersing Agents, Mixing and Grinding Aids, Freeze Thaw Stabilizers, Stearates
Silvain Arthur McCready Leonard
Bryant Lohrke Licata
— **See Advertisement Page 154** —

NUODEX PRODUCTS CO. 314-315
New York 17, N. Y.
Nuodex PMA-15—Mildewcide for Aqueous systems, Nuodex DLG-10—Dispersable Zinc Stearate for Lacquer Sanding Sealer, Nuostabes—Stabilizers for Solutions, Organosols and Plastisols
Minich O'Neil Houston Burns
Dwyer Clark Galbraith Kaiser
Price Stewart Goodfellow Lang
— **See Advertisement Pages 106, 107** —

O

ORONITE CHEMICAL CO. 455
San Francisco 20, Calif.
Isophthalic, Phthalic Anhydride, Phenol
Stephenson Hathaway Burge Webb
Lilla Billings Gould Johnson
— **See Advertisement Page 108** —

P

PACIFIC VEGETABLE OIL CORP. 442
San Francisco 8, Calif.
Drying Oils, Safflower Oil, Safflower Methyl Esters
Hammond Hagen
— **See Advertisement Page 35** —

PATTERSON FOUNDRY & MACHINE CO. 409-410
East Liverpool, Ohio
Ball and Pebble Mills, High Density Mill Linings, Grinding Media, High Speed Dispersion Mills, Synthetic Resins System
Darrah Wilhelm Witherow Wright
Gantt Hood Dolan Jacobson
Callahan Cantle Brown Custis

PENNSYLVANIA INDUSTRIAL CHEMICAL CORP. 309
Clairton, Pa.
Piccolyte, Piccolastic Bronze Vehicle, Coumarone-Indene, Cationic, Nonionic and Anionic Petroleum Emulsions, Piccotex, Piccoflex
Wilson Jackson Kelly Davis
O'Rourke Patureau Wolfe Steinmark
Stevenson Yound
— **See Advertisement Page 145** —

R

R-B-H DISPERSIONS 308
Div. of Interchemical Corp.
Bound Brook, N. J.
Pigment Dispersions
Craft Lynch Conklin Garrison
Galowitsh Norris Farnsworth

REICHHOLD CHEMICALS, INC. 451-453A
White Plains, N. Y.
Melamine Resins, Alkyd Emulsions
Baker Bloomquist Breedlove Drake
Durr Estrada Fay Knauss
Leever Pinkerman Reali Swisher
Weinmann Weismann Wilson
— **See Advertisement Second Cover** —

ROHM & HAAS CO. 401-402
Philadelphia, Pa.
Rhoplex, Duraplex, and Amberlac Resins
Adamson Alcorn Allyn Bennett
Bretl Cheetham Collins Gibson
Grinsfelder Keyser Klein Maloney
Oliver Prentiss Sohl Tetzlaff
Timmons Toussaint Urquhart Wallman
Weiss
— **See Advertisement Page 110** —

ROSS & ROWE, INC. 325
New York, N. Y.
Lecithin for Paints, Interface Modifier for Latex Paints, Viscosity Modifier
Schlesinger Hilty McAuley Kruse

CHARLES ROSS & SON CO., INC. 427
Brooklyn 5, N. Y.
Three Roller Mills, Dispersion Change Can Mixers, Paste Mixers, Change Tank Mixers, Double Arm Kneaders, Liquid and Semi-Paste Mixers, High Speed Dissolvers
L. Ross C. Ross Teleky
— **See Advertisement Page 147** —

S

SHARPLES CHEMICAL DIV. 437
Pennsylvania Salt Mfg. Co.
Philadelphia, Pa.
Solvents for Hot Lacquer, Anti-Livering, Anti-Skinning Agents, Emulsifiers, Paint Remover Ingredients and Stabilizers, Gardner-Sharples Blush Cabinet

Baum Eaton Kayser Geiser
Hoover McKinney Rowe Sideroff

— See Advertisement Page 153 —

SHAWINIGAN RESINS CORP. 454
Springfield, Mass.
Polyvinyl Butyral, Polyvinyl Acetate, Polyvinyl Formal, Polyvinyl Alcohol, Polyvinyl Acetate Copolymer, Acetic Acid, Ethyl Acetate

Bromley Wilson Dunning Poole
Young Porter Morrison Hoyt
Finsilver Hill

— See Advertisement Page 8 —

SHELL CHEMICAL CORP. 311-312
New York 17, N. Y.
Epoxy Resins, EAK, MIBK, MEK, DMK, MIBC, IPA

Bradley Buller Cosgrove Curry
Fitzsimmons Herr Howard Jones
McGuigan Mozo Murdock Naumann
Norton O'Connell Robbins Selden
Somerville Swackhammer Williams Dunbar

— See Advertisement Page 6 —

SHELL OIL CO. 338-339
New York 20, N. Y.
Odorless Solvents

Shaffer Preu Conn Myers
Waters Ferruci Reynolds Nonweiler
Carnahan Gilbert Martin Rank
Irwin Dixon Sliwa Pugh
McHenry Kingsbury Thomas

— See Advertisement Page 14 —

SILBERLINE MFG. CO. 441
Stamford, Conn.
Aluminum Pigments

Scheller Usowski Smith

T

TALL OIL ASSOC. 444
New York 17, N. Y.
Crude and Refined—Distilled Tall Oil
Members of the Association will be present

THIBAULT & WALKER CO. 443
Newark, N. J.
Vehicle line

Van Tuin Salmon Norton Parker
Dunn Sigafoos Edelstein

TROY CHEMICAL CO. 445
Newark, N. J.
Mildewcides, Puffing, non-sagging and non-settling agent, Anti-skinning Agents

Singer Sockloff

— See Advertisement Page 121 —

TROY ENGINE & MACHINE CO. 421
Troy, Pa.
Angular Mixer, Roller Mills, Colloid Mills

Parson Harrigan Herrington Brasington

— See Advertisement Page 114 —

U

UNION BAG & PAPER CO. 349
New York, N. Y.
Tall Oil Line—Acid and Fractionated Types

Durand Fiscella Zachary

— See Advertisement Page 129 —

U. S. STONEWARE CO. 457
Akron, Ohio
Ball Mills, Jar Mills, Mill Jars, Grinding Media

Farkas Scales Gomoll Gross

— See Advertisement Page 151 —

W

T. F. WASHBURN CO. 425
Chicago 14, Ill.
Thixotropic Paint Vehicles

C. Smith Contos L. Smith Bennett
Neher

C. K. WILLIAMS & CO. 310
Easton, Pa.
Panels showing paints formulated with Various Iron Oxide Pigments, Cuprous Oxide as Mildewcide, Chromium Green Oxides

Burris Kroepel Green Crumpler
Thayer Clare Richards Love
Hathaway Jeffrey Stephens Stewart
Mix Dubbeldeman Steubing Alexander
Thomsen Lippincott Fuller

WITCO CHEMICAL CO. 417-418
New York 17, N. Y.
Emulsifier, Paint Driers, Plasticizers, Carbon Black, Precipitated Calcium Carbonate, Metallic Stearates

Armato Dowlen Gardner Hobach
Kaszynski Vaccaro Vaughn Weiss
Wendt

— See Advertisement Pages 142, 162 —

COLOR METRIC EXHIBITS — North Exhibit Hall
Instrument Develop Labs.
General Electric Co.
Macbeth Daylighting Corp.
Curry & Paxton
Container Corp. of America
Mfgrs. Eng. & Equipment Co.
Gardner Laboratory

LACQUER INFORMATION CENTER
Antara Chemical Div.
General Aniline and Film Corp.
Carbide & Carbon Chemicals Co.
Div. Union Carbide & Carbon Corp.
Celanese Corp. of America
Enjay Co., Inc.
Hercules Powder Co.
Davison Chemical Div.
W. R. Grace & Co.
Olin Mathieson Corp.
Penn Salt Co.
Shell Chemical Corp.
Columbian Carbon Co.
Sprayon Products, Inc.

OTHER EXHIBITS
Heckel Publishing Co.
Evaporometer — New York Club

PAINT INDUSTRIES' SHOW SCHEDULE

Mon.	*Oct. 22*	*1:00 P. M. - 9:00 P. M.*
Tue.	*Oct. 23*	*9:00 A. M. - 5:00 P. M.*
Wed.	*Oct. 24*	*1:00 P. M. - 6:00 P. M.*

6 to 9 months longer shelf life for your polyvinyl acetate and latex base PAINTS!

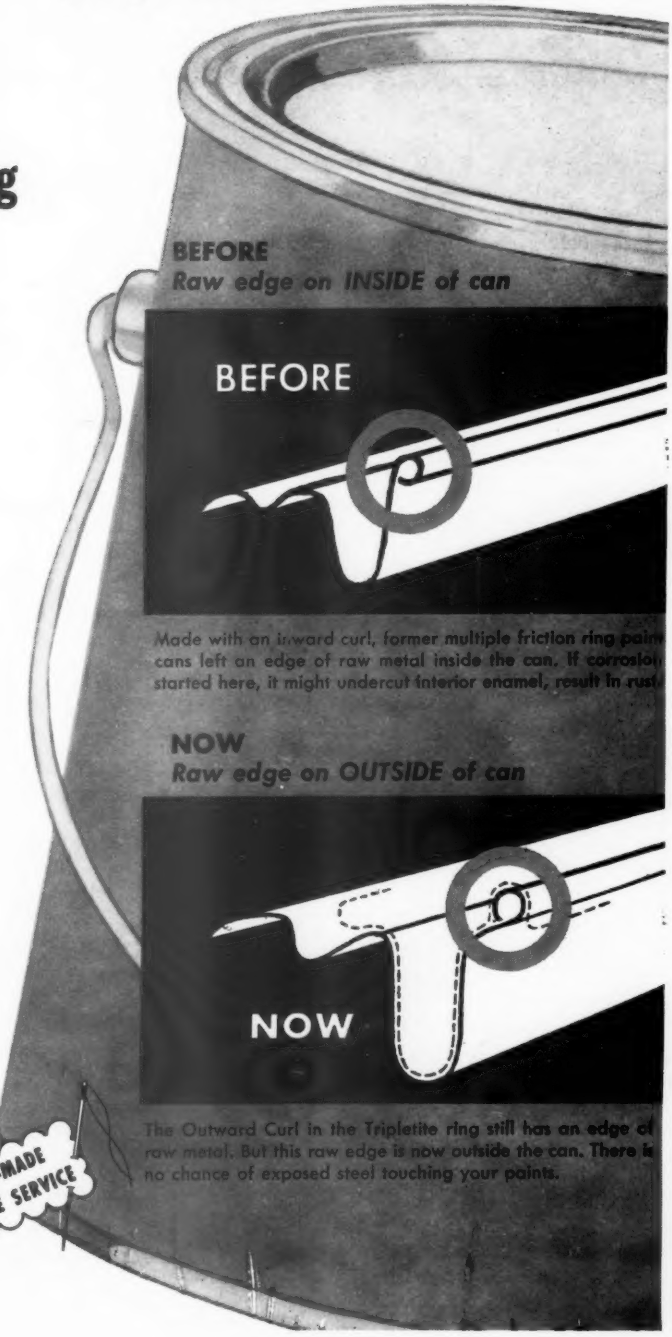
No raw metal— complete inside enameling with Continental's new

Outward Curl Ring

Store and laboratory tests prove it. You can give your polyvinyl acetate and latex base paints 6 to 9 months longer shelf life with Continental's new Outward Curl paint cans.

This improved container is made with the Tripletite friction ring curled outside the can. Every square inch of inside surface is enameled—and your paints never touch raw metal. In addition, you get the protection of Continental's Tripletite lid. Imagine what your salesmen can do with a story like this.

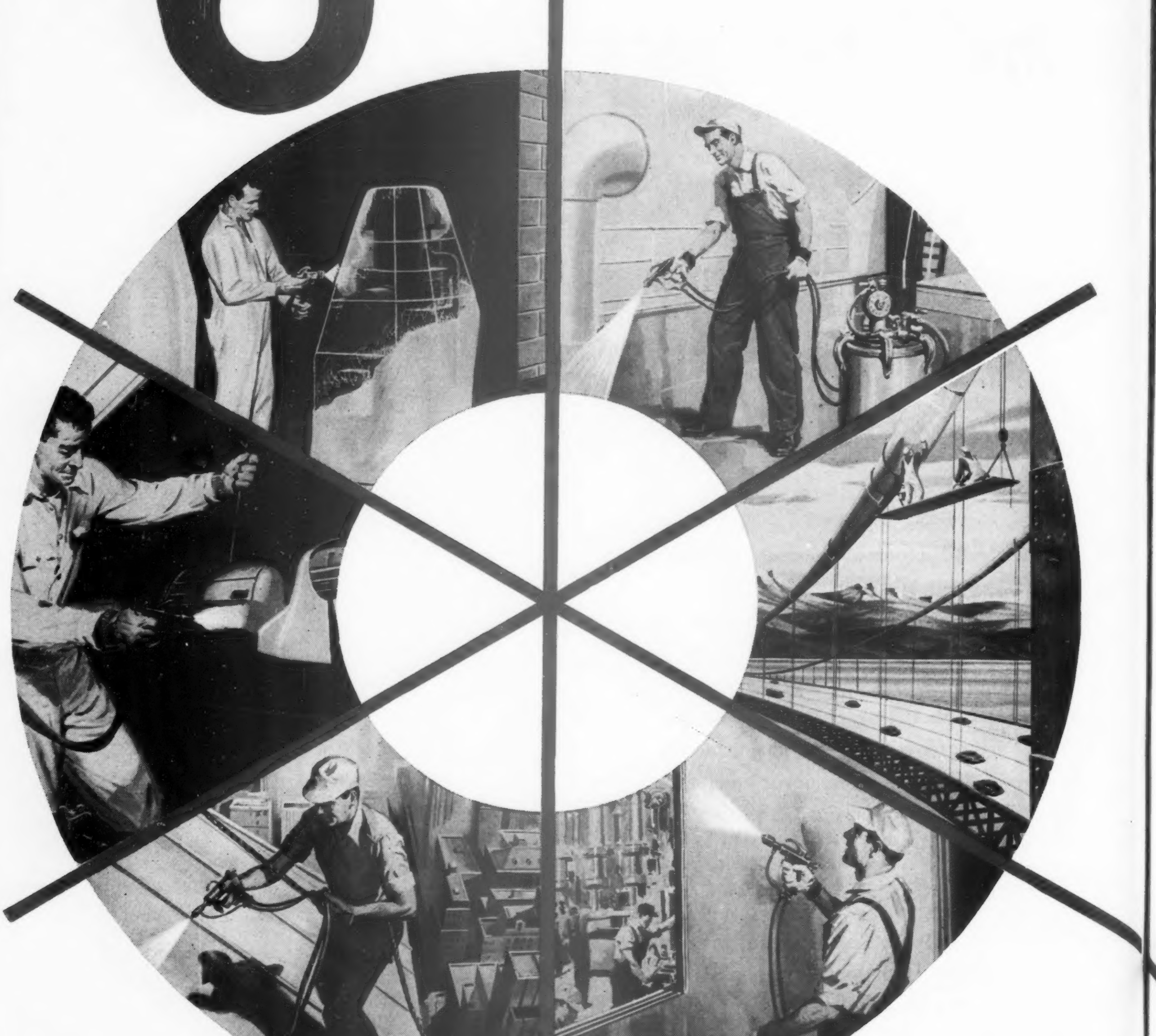
Outward Curl paint cans are ready to work for you now. Just call your Continental representative for full details. We aim to give you the most modern in tailor-made service as well as the most modern in containers.



CONTINENTAL CAN COMPANY

Eastern Division: 100 E. 42nd St., New York 17
Central Division: 135 So. La Salle St., Chicago 3
Pacific Division: Russ Building, San Francisco 4

6 solutions for your



protection problems...

EXON

SOLUTION RESINS

Protective coatings take many forms to fill many needs . . . whatever you need, you will find your answer among the 6 solution resins of Firestone Exon.

Each resin is engineered specifically for the individual requirements of each application. Their properties vary. Some strip clean in seconds, some hold fast for years.

But all of them spray smoothly, dissolve quickly in appropriate solvents, resist chemicals, abrasion, corrosion and weather to an unusual degree.

Exon solution resins are industry's primary source of dependable, low cost, enduring protection, for they are used extensively by makers of all types of coatings. They are 6 sound reasons why industry looks to Exon for engineered answers to its needs.

EXON 450
Ideal for strip coatings. Good solubility, tensile strength and durability.

EXON 461
A unique fluorine-containing resin combining high solubility, unusual chemical resistance, heat stability and weatherability.

EXON 470
Excellent adhesion to metals, alkyd and vinyl surfaces. Compatible with wide range of drying oils, alkyds, phenolics, melamines. High solubility in inexpensive solvents.

EXON 471
Excellent for weatherability and durability in a protective coating. Corrosion resistant. No measurable change after sunlamp exposure for 360 hours as 1 mil film.

EXON 481
Makes possible colorful, abrasion-proof, washable coatings that resist fading or cracking.

EXON 485
For superior strip coatings. Lower viscosity makes application easier and shelf-life better. Good clarity.

Firestone

For details that will interest you in particular, call or write:

CHEMICAL SALES DIVISION

FIRESTONE PLASTICS COMPANY, DEPT. 630N POTTSTOWN, PA. A Division of The Firestone Tire & Rubber Company

NEWS

Rexton Finishes Elects Leo Roon A Director

Rexton Finishes, Inc., Irvington, N. J., manufacturers of a complete line of industrial finishes, has announced the election of Leo Roon as a director of the company.

Leo Roon

Mr. Roon, founder and former president of Roxalin Flexible Finishes, Inc., is well known in the protective coatings field, having also established Nuodex Products Co., Elizabeth, N.J., of which he was president until 1954.

Although presently retired from active business, Mr. Roon is also serving as a director on the Boards of Houghton Laboratories, Inc., Olean, N. Y.; Roxalin of Canada, Ltd., New Toronto, Ontario, Canada; Eastern Long Island Hospital Greenport, New York, and Columbia University College of Pharmacy.

•

Atlas President Retires

Kenneth R. Brown, vice president and director of Atlas Powder Co., retired Aug. 31 after 38 years' service.

Mr. Brown's pioneering work in developing the commercial production of sorbitol won him the 1955 honor awards of both the American Chemical Society's Division of Carbohydrate Chemistry and the Commercial Chemical Development Association.

•

New Gilsonite Agent

The American Gilsonite Co. has appointed Allied Asphalt & Mineral Corp. its distributor for all less carload sales of Barber Gilsonite formerly supplied by American Gilsonite from its Barber, New Jersey warehouse. The announcement was made by George J. O'Sullivan, vice president and general manager of Allied Asphalt & Mineral.

New Low Cost...

Paints based on BAKELITE BRAND

will be featured at Bakelite

Now unusually high pigment-volume ratio!

You will see how the *new higher pigment loading* possible with BAKELITE Brand Polyvinyl Acetate Latex WC-130 can work to *bring down formulating costs*... increase ease of tinting and uniformity of appearance... without sacrifice in washability. Hiding power with one coat of white or light tint is excellent. See the results for yourself at the BAKELITE booths.

Other New Developments with WC-130 Latex

Other developments based on WC-130 to be introduced are a sealer featuring superior characteristics at low temperature... wood fillers for use under furniture lacquers . . . and the latest in test results on WC-130 Latex based paints for exterior application.

See Bakelite Company's
Booths Numbers 331-332-333
Oct. 22, 23 & 24—1956 Paint Industries' Show
Netherlands Plaza Hotel, Cincinnati, Ohio

NEWS

Schroeder, of A-D-M, To Attend Harvard Program

Burton W. Schroeder, assistant vice president and assistant to the president, Archer-Daniels-Midland Co., has been selected to attend the fall session of the Advanced Management Program at Harvard University.

B. W. Schroeder

The session, Harvard's 30th, began Sept. 12 and will last through Dec. 7. The program is designed for executives to give them a broader understanding of management's function in business.

Mr. Schroeder was appointed assistant to the president last October. Prior to that he was sales manager for ADM industrial cereals and vegetable fatty acids. He was elected assistant vice president in February 1955. Mr. Schroeder joined ADM in 1939 upon graduation from the University of Michigan.

Following one year's service as a control chemist at the Milwaukee plant, he was transferred first to the Minneapolis control and then to the research laboratory where he stayed until 1943 when he entered the Navy. Upon his return from service in 1946, he conducted market research on industrial cereals and started the division to produce and sell these products. He was named manager of the vegetable fatty acids department in 1948 and was again placed in charge of the industrial cereals division in 1954. A chemical engineer, Mr. Schroeder is a member of the American Chemical Society.

Chemical Exposition

The Ninth National Chemical Exposition, trade show of the entire chemical industry will be held Nov. 27-30 in the Cleveland Public Auditorium, Cleveland, Ohio. The show is co-sponsored by the Cleveland and Chicago sections,

Hercules to Expand Oxychemicals Production

Plans for an extensive addition to production facilities at its oxychemicals plant in Gibbstown, N.J., were recently announced by Hercules Powder Co.

The expansion program at the synthetic phenol plant, the East Coast's newest, will involve doubling the production capacity of para-cresol and its derivatives, chemicals used in a variety of industries including petroleum, foods, and essential oils.

A previously announced addition at Gibbstown for the production of three million pounds of paracresol annually, together with facilities for its conversion to di-tert-butyl-para-cresol (butylated hydroxytoluene), is scheduled for completion late in October or November. Under the new expansion program, the capacity of this unit will now be increased to six million pounds of paracresol annually. The production capacity of di-tert-butyl-para-cresol will also be doubled.

Color Film Available

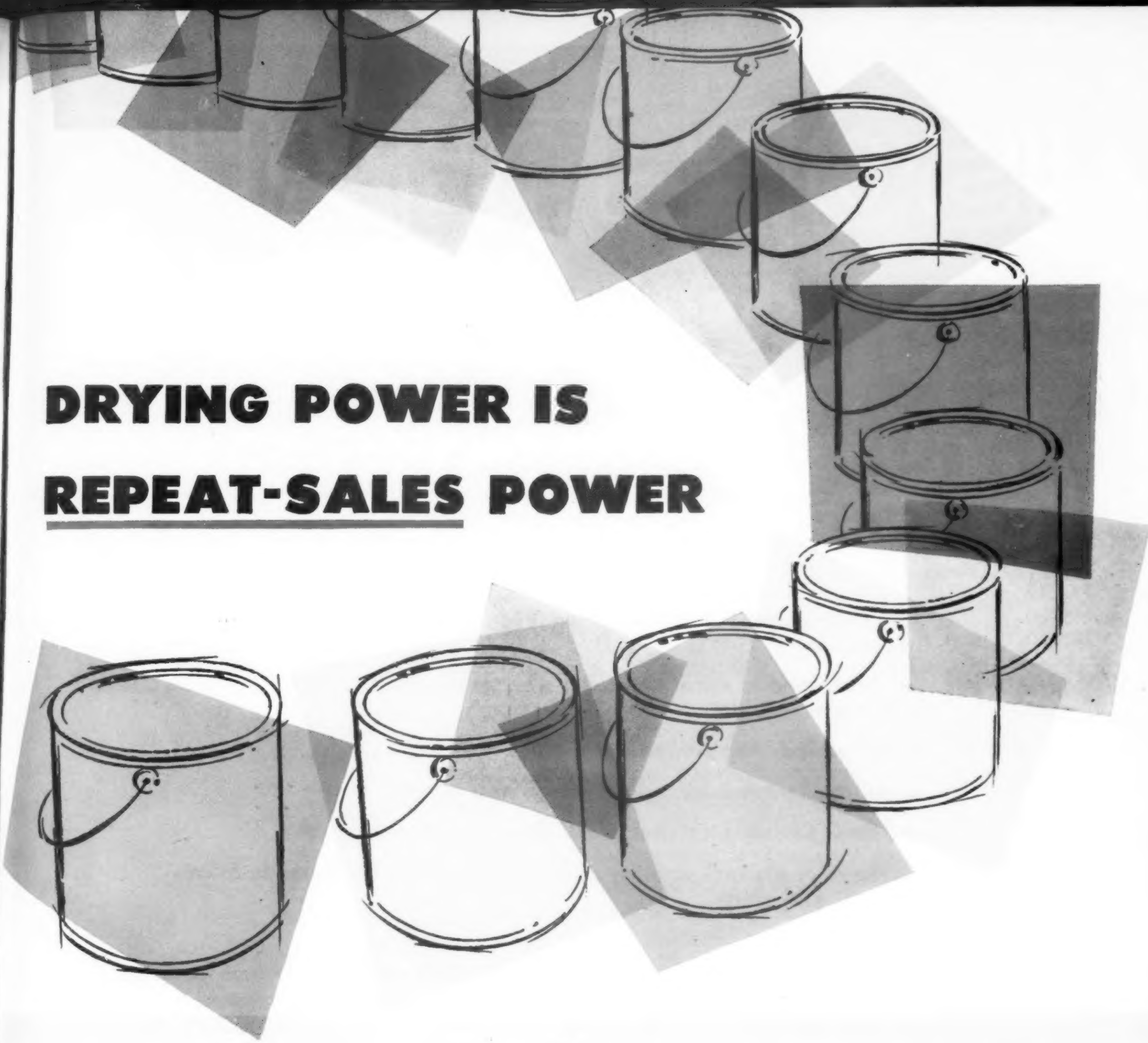
"Miracle in Color," a 16-mm sound motion picture in Kodachrome, 15 minutes in length, is available through The Dow Chemical Co., producer of synthetic latexes used in many brands of latex paint.

Architects, painting and building contractors and maintenance officials may obtain a copy of the film for group showing by contacting The Dow Chemical Co., Plastics Sales Dept., Merchandising Section, Midland, Mich.

McCloskey Warehouse

McCloskey Varnish Co., Philadelphia, last month opened a warehouse at 1149 Jefferson Ave., Memphis, Tenn., to stock its complete line of varnishes and natural wood finishes.

Frank C. Peck, vice preisdent and national trade sales manager, reports that the firm now has salesmen covering all of this central southern part of the United States including Louisiana, Mississippi, Arkansas, Alabama, Tennessee, Texas, and Oklahoma. The new warehouse will permit faster shipments of McCloskey products to these retail outlets.



DRYING POWER IS REPEAT-SALES POWER

"Feeder" action of Nuact® Paste stops loss-of-dry

You know what happens when a customer buys a can of your paint that doesn't dry. You've lost a customer and jeopardized your brand reputation. Repeat sales are won or lost on warehouse floors and on dealers' shelves . . . and here Nuact Paste is a time-proved winner.

Nuact Paste is a patented lead compound with "feeder" drier action. Other methods of protecting dry are dangerous. Overloading with drier may cause wrinkling or skinning; better drier balance, with three or four driers, raises costs. The secret of Nuact Paste is that it becomes active slowly and in controlled amounts over extended periods of time. It features minimum settling, greater solubility and stability. In addition, Nuact Paste presents no dusting problem and actually adds to the paint yield.

Nuact Paste is strongly recommended for systems containing adsorptive pigments, particularly these bad actors: Carbon Blacks, Prussian Blues, Iron Oxides, Chrome Greens, Para, Toluidine and Lithol Reds, and Titanium Whites.

Rely on Nuact Paste for customer insurance—insurance against costly adjustments and that "silent loss of business" when paints fail to dry properly. Make a trial of Nuact Paste in your own paint and enamel systems. Write us direct for full information and samples, or contact your Nuodex Representative.

P. S. To inhibit loss-of-dry in lead-free systems, Nuodex Cobalt 254 is recommended.

NUODEX ADDITIVES
—TO MAKE GOOD PAINTS BETTER

THREE LITTLE BOTTLES
THAT BUILT THE PLANT

NUODEX PRODUCTS COMPANY... 342 MADISON AVENUE, NEW YORK 17, N. Y.
A Division of Heyden Chemical Corporation

1...2...3... GO!

TRIMETHYLOLPROPANE

another new aldol product from Celanese

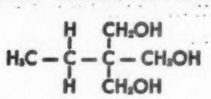
1 In continuous large volume . . .
2 With exceptionally high purity . . .
3 At a new low cost . . .

For all producers of polyurethanes and alkyd resins, Celanese expanded production of trimethylolpropane—in the right volume, quality, and at a new low price—is important news.

No longer will it be necessary to pass up the processing and product improvements this polyol can contribute. Now manufacturers can take full advantage of the better adhesion, color, color retention, and hardness it provides in alkyd-based baking enamels . . . the greater mixing ease it offers in compounding polyesters and pre-polymers with diisocyanates.

The way is also clear now for the commercial development of other indicated uses for trimethylolpropane—in the production of synthetic drying oils, plasticizers, surface active agents, polyesters. For working samples and prices write to Celanese Corporation of America, Chemical Division, Dept. 558-J180 Madison Ave., N. Y. 16.

CELANESE* TRIMETHYLOLPROPANE



Descriptive Data

Hydroxyl value, % by wt., min.	37.5
Water content, % by wt., max.	0.05
Color (10% soln.), APHA, max.	5
Phthalic color, Gardner, max.	1
Acidity, as formic, % by wt., max.	0.002

Q. **Why can Celanese produce trimethylolpropane at a price well below that of comparable purity grades?**

A. Through the production efficiencies and economies of expanded aldol capacity . . . special Celanese-developed processes . . . and a basic position in aldehydes.

Trimethylopropane is the second in a new series of aldol developments and will be followed by several others—new polyols, glycols and aldehydes. Celanese* 3-Methoxy Butanol, first in the series, is already being produced in large quantities.

Celanese* CHEMICALS

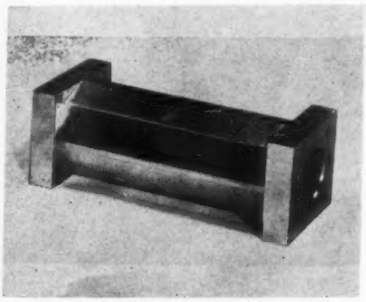
*Reg. U. S. Pat. Off.

PVP

NEW MATERIALS & EQUIPMENT

A MONTHLY MARKET SURVEY

This section is intended to keep our readers informed of new materials and equipment. While every effort is made to include only reputable products, their presence here does not constitute an official endorsement.



SHELL OIL

PAINT FILM APPLICATOR
Has 4 Doctoring Edges

Four-edged applicator designed to apply a controlled thickness of paints and varnishes to panels for testing purposes has been developed by Shell Oil Company's new paint research laboratory at Wood River, Ill.

Known as the "Shell Multiple Doctor Blade", this applicator contains four "doctoring" edges instead of only one as in conventional applicators.

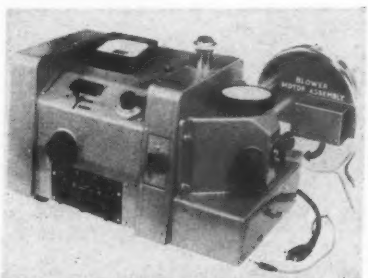
The applicator is shaped like a dumbell—except that its shaft is octagonal and its ends are square. The four "blades" are the four edges of the octagon that come to the middle of the sides of the squares. The clearance between the side of the square and the edge of the octagon determines the thickness of the paint film the blade will spread.

To use the applicator, paint or varnish is first placed on the selected surface-glass, metal, etc. Then the applicator, with the desired edge face down, is passed over the surface to spread the paint or varnish according to the thickness desired. The spread material is then tested for weather-resistance, etc.

According to the inventor, this applicator can be made by any machinist. For further details, write to Shell Oil Co., Dept. PVP, 50 W. 50th St., New York 20, N. Y.

COLORIMETER
Dual-Purpose

To provide for color difference determination in temperature-sensitive materials and to make accurate color measurement possible in dusty atmospheres, a cooling system and air filter has been added to the Model C Color-Eye. The Model C Color-Eye is a colorimeter designed for quality control of industrial colors in raw materials and



INSTRUMENT

in finished products. It performs the dual functions of an abridged spectrophotometer and a tri-stimulus colorphotometer in analyzing color formulations, determining metameric conditions and quickly measuring color differences in hue, value and chroma. The cooling system reduces the temperature rise at sample ports and maintains it at a point where rapid analysis of colors on temperature-sensitive materials is possible. The replacement-type filter removes dust from the incoming air to prevent dirt deposition from decreasing the sensitivity of the optics.

For further details write to Instrument Development Laboratories, Inc., Dept. PVP, 67 Mechanic Street, Attleboro, Mass.

PVA LATEX
Small Particle Size

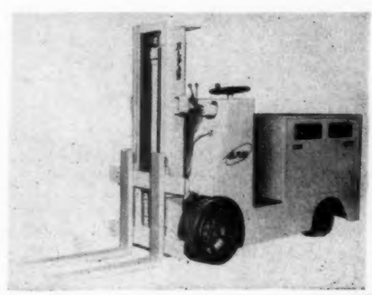
"Acetex 2700" is said to be a new and different type vinyl acetate copolymer latex with an extremely small particle size and a different emulsifier system—providing a more satisfactory vehicle for interior and exterior paints. Improved properties claimed are pigment binding capacity; exterior durability; scrubbability; gloss; film clarity; water resistance. The particle size is approximately 0.2 microns. Because of this size, it is said to have improved ability to surround pigment particles and bind them. The new emulsifier system is claimed to enhance the properties of the copolymer in paint. Naugatuck Chemical Div., United States Rubber, Dept. PVP, Naugatuck, Conn.

ELECTRIC FORK TRUCK
Center Control

Electric-powered, stand-up, center control fork truck, has a capacity of 10,000 lbs. Designated as its RIOT model this fork truck features front wheel drive, rear wheel steer, and travels 4.5 mph without load, 4 mph with a full load, according to the manufacturer. Direction and acceleration are through a single hand control lever.

Elwell-Parker Electric Co., Dept. PVP, 4205 St. Clair Ave., Cleveland, Ohio.

ELWELL-PARKER



N E W
MATERIALS — EQUIPMENT

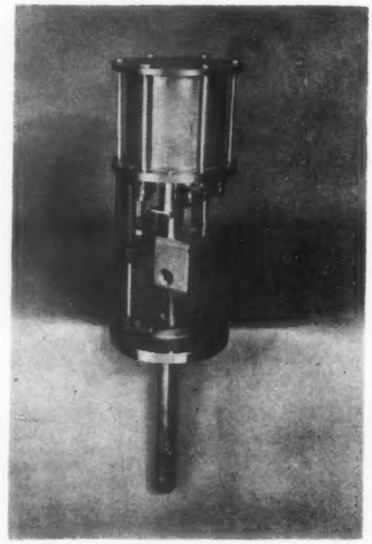
ISOCYANATES

Varied Uses

Company is offering two new isocyanates said to be suitable for many applications never before offered in semi-commercial quantities.

"PAPI" (Polyaryl Polyisocyanate) is a dark-amber, somewhat viscous liquid belonging to the aromatic polyisocyanate family. Because its average functionality is equivalent to a tri-isocyanate, it is expected to provide superior utility in numerous applications involving the reaction of isocyanates with substances containing activated hydrogen atoms. In coating applications, for example, it is reported that polyisocyanates are excellent for bonding rubber and other elastomers to cloth such as nylon and rayon. "PAPI" is therefore expected to prove advantageous for the manufacture of neoprene coated tarpaulins, rubber coated protective clothing, and fast drying alkyds and drying oils of improved quality.

"BuNCO" (n-Butylisocyanate), a water-white, liquid, aliphatic monoisocyanate, it is capable of undergoing all the reactions typical of this class of compound, and is said to be less sensitive to moisture than the aromatic members of this family. It is claimed to offer an immediate and simple route to substituted ureas and urethanes for numerous uses. The Carwin Co., Dept. PVP, North Haven, Conn.



NORCROSS

VISCOMETER

Electric-Pneumatic Type

Electric-pneumatic-viscometer measuring elements line (M7, M8, M9 and M10) operate on the basic principle of falling piston. An air lifting mechanism is used to raise the piston assembly drawing a sample in through the tube openings. The sample then passes down through the clearance between the piston and the inside of the tube into the space formed in the lower end of the tube when the piston is raised. The lifting mechanism is then quickly lowered and the time required for the piston to fall to the bottom of the tube expelling the sample out through the same path as it entered is a measure of viscosity.

The illustration is the Model M10 used for measuring viscosity under pressure or vacuum conditions requiring explosion-proof equipment. This Model is for pressures from full vacuum to 100 psig and can readily be modified for higher pressures. This model is also suitable for reactors providing complete viscosity information during polymerization. It is also appliable to pipe lines in many instances.

IT'S PERFORMANCE THAT COUNTS!

PHILLIPS 66
SOLTROL*
ODORLESS MINERAL SPIRITS

For high quality performance choose Phillips *66* Soltrol. If you want conventional drying characteristics, ask for Soltrol 130. For longer wet edge, it's Soltrol 170. These odorless, water-white thinners are available in 4,000 or 8,000 gallon tank cars . . . or in 6,000 gallon compartment cars containing both Soltrols.

Free Test Samples

We want you to test Soltrol and see for yourself how Soltrol performs in your product. Send for free samples of Phillips *66 odorless* thinners.

**A trademark*

ODORLESS MINERAL SPIRITS

SOLTROL

66

PHILLIPS PETROLEUM COMPANY
SPECIAL PRODUCTS DIVISION
BARTLESVILLE, OKLAHOMA

NEW MATERIALS — EQUIPMENT

These new Measuring Elements are said to measure viscosities from .1 to 1,000,000 cp.

Contact Norcross Corp., Dept. PVP, Newton 58, Mass. for further information describing this equipment.

PAINT LATEX

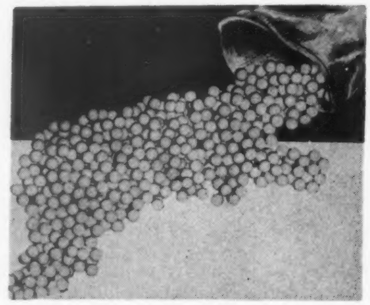
Fortified Styrene-Butadiene Type

"Dylex" latex K-34 is a styrene-butadiene copolymer fortified during polymerization with an additional ingredient that enhances the properties of the latex, the manufacturer claims.

One factor contributing to improved characteristics in the new latex is its fine particle size. According to the producer, this latex possesses increased pigment binding strength and improved adhesion to a variety of surfaces, and good freeze-thaw stability. The manufacturer also claims that paints formulated with this particular latex may be prepared with water dispersible pigments and low cost extenders. In addition, paints containing the new latex retain their pigment binding strengths even with high PVCs—for example, durable films have been achieved in paints having a PVC as high as 43%.

Paints formulated with this latex are said to have the following properties: ease of application, and clean-up, good scrubbability, ease of stain removal, good leveling and covering, uniformity of sheen, and good enamel holdout. Available in 55-gal. non-returnable drums, or in tank car or tank truck lots.

Koppers Co., Inc. Dept. PVP, Pittsburgh 19, Pa.



McDANEL

GRINDING BALLS

Have Longer Wear

Improvement in recent manufacturing changes, higher firing temperatures, new body formula have resulted in an improved high density grinding ball that retains its shape and wears much longer than ordinary grinding balls, according to the manufacturer. The manufacturer also claims that complete vitrification of the grinding ball means greater weight, more toughness, less pick-up, and faster grinding. They have a specific gravity of 3.3, which means faster grinding. Greater hardness is also said to mean that smaller balls can be used, further increasing grinding speed.

Batch sizes can be increased with these high density grinding balls over porcelain or flint pebbles. Sizes available range from ½" to 2½". 3" sizes are made upon request.

For further information write to McDanel Refractory Porcelain Co., Dept. PVP, Beaver Falls, Pa. and request Bulletin No. Bl-56.

THICKENING AGENT

Not Affected by Moisture

Viscotrol-A is said to impart thixotropic body to polar, non-polar aromatic and aliphatic solvents as well as to non-solvent containing liquid resins and plasti-

cizers. This thickening agent is a non-yellowing, finely divided powder which is practically odorless and tasteless and is not affected by moisture. Recommended for paints, varnishes, finishes, plastics, printing inks, etc. Another feature claimed for this thickening agent is that: it is impervious to the effects of impurities such as water, phenols, polar solvents, basic or acidic components.

In finishes it imparts the following properties, according to the manufacturer: controls viscosity, controls sagging and flow, prevents pigment settling, improves brushability, controls penetration, and better leveling, will not affect rate of drying, scratch resistance, adhesion, color, gloss.

Ferro Chemical Corp., P.O. Box 349, Dept. PVP, Bedford, Ohio.

PIGMENT PASTES
Non-Hygroscopic

Paste pigments are said to be non-hygroscopic, non-oxidizing, non-corrosive, and non-hydrolizing in the presence of water, acids, or alkalis.

An oily-like viscous liquid which remains permanently plastic is the wetting agent used in these pastes. This wetting agent is used to lubricate, coat, and polish metallic pigment flakes, producing a pigment paste possessing durability, permanence, brillance, luster, and high gloss. One feature claimed by the producer is that copper and bronze pastes do not discolorize and oxidize, even when exposed to moisture and corrosive conditions.

Chemical Sealers, Inc. Dept. PVP, Belleville, Ill.

FUNGICIDE
Soluble in Water, Solvents

"Meta-San O" and "Meta-San W" are mercurial type funcicides for oil base paints and water base paints respectively. These are liquid preparations. In solid form the product is called "Meta-San". According to the producer, this product has great solubility both in water and a wide range of organic solvents. Because of this particular solubility property, this chemical is suited as an effective mildewcide and preservative. Metalsalts Corp., 200 Wagaraw Rd., Dept. PVP, Hawthorne, N. J.

HIGH SPEED CENTRIFUGE
For the Laboratory

Spinco model K centrifuge has maximum speed of 25,000 rpm with forces of 50,000 times gravity on 160ml of material. This unit is driven with a constant-speed motor. Range of 20 speeds from 2,500 to 25,000 rpm can be obtained by interchangeable series of pulleys.

Inclined-tube rotors run in air. Through the use of a special design including an insulating layer bonded to rotor, operation can be carried out a room temperature without refrigeration, according to the manufacturer. Spinco Div., Dept. PVP, Beckman Instruments, Inc., 714 O'Neill Ave., Belmont, Calif.

POLYGLYCOLS
Chemical Intermediates

Polyepichlorohydrin, polystyrene glycol and polybutylene glycol are expected to find application in paint, plastic and coating industries. Because of improved characteristics, these products are expected to increase widely the use of polyglycols as chemical intermediates in processes which place stringent demands on chemical intermediates. These include the manufacture of polyurethanes and emulsifiers. These polyglycols are now being produced in pilot plant quantities.

Dow Chemical Co., Dept. PVP, Midland, Mich.

NEWS

P. B. Mitton, of Nat. Lead, Wins N.Y. Paint Club Prize

Parker B. Mitton of National Lead Company's titanium division research laboratories in Sayreville, N. J., has been awarded first prize by the New York Paint and Varnish Production Club in a contest for papers submitted by paint technology students in the New York area.

P. B. Mitton

His paper was entitled "Hiding Power from Photometric Measurements Only." Mr. Mitton entered the contest as a student of Prof. Fred Bauder of the Newark College of Engineering, where he has been taking courses to extend his knowledge in the field of paint technology.

He is a graduate of the University of New Hampshire, holding a Bachelor of Science degree. In 1948 he was employed by National Lead and presently is group leader in charge of pigment vehicle research at the Sayreville research laboratories.

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Diamonite Appoints Young

Diamonite Products Division, United States Ceramic Tile Co., Canton 2, Ohio, has announced the appointment of Jesse S. Young Company, Inc., 2 Park Ave., New York 16, N. Y., as sales agent for its Diamonite High Density Grinding Rods in the metropolitan New York area, including northern New Jersey and Connecticut. The company acts as sales representative for manufacturers of materials and equipment used in the paint and chemical industry.

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Carbide Moves N. Y. Sales

Carbide and Carbon Chemicals Co., a Division of Union Carbide and Carbon Corp. has moved its New York district sales office to 100 E. 42 St., New York 17, N. Y. The new telephone number is MUrray Hill 6-5100.

PERSONNEL CHANGES

VULCAN CONTAINERS

Lawrence M. Ferguson, an 18-year veteran with the company, has been promoted to sales manager, it was announced by Herbert B. Scharbach, vice president for sales.

L. M. Ferguson

An authority on interior coatings for steel shipping containers, Mr. Ferguson has been instrumental in the research and development of the company's techniques in varied coatings for the interior of steel shipping pails making them suitable for packaging such diverse products as foods, chemicals, and petroleum products. He also has been instrumental in the development of Vulcan's storage warehouse facilities at the Bellwood, Ill., plant.

E. R. Egloff

F. H. Mrozek

ACHESON COLLOIDS

E. Ralph Egloff and **Frank H. Mrozek** have been appointed service engineers. Mr. Egloff has been assigned to the Chicago sales office, while Mr. Mrozek will be located in the New York office.

Mr. Egloff's business background includeds two years of industrial sales, during which time he represented machine tool firms in the Chicago area.

Mr. Mrozek, prior to joining the Acheson organization, was a technical assistant at the Bell Telephone Laboratories for four years.

EVANS RESEARCH

Gerald Fishman, formerly of Affiliated Research, Inc., **Ruth Fierman,** formerly of Jacobs Winston Laboratories, and **Stanley Lerner,** formerly of Columbia University, have been added to the staff as research chemists, it was announced by Dr. Eric J. Hewitt, vice president.

BAKER CASTOR OIL

Hyman M. Metz, who was associated with the application laboratory of the Heyden Chemical Corp. from 1953 to 1956, has joined the Baker sales service staff as head of the protective coatings laboratory.

Oscar G. Lustig is now on the research laboratory staff as an organic research chemist. He was employed by the Palestine Potash Co. as a chemist from 1943 to 1948, and by Fine Organics, Inc., Lodi, N. J., from 1952 to 1956.

CARGILL

Richard A. Simmonds, for the past seven years in technical sales for two leading chemical firms, has joined the oils division in a technical sales capacity, according to Fred M. Seed, vice president in charge of the division.

HEYDEN CHEMICAL

Walter C. Deakyne, Jr., has been appointed assistant general sales manager, according to an announcement by Thomas O'Neil, vice president in charge of sales and marketing.

W. C. Deakyne

Mr. Deakyne has been with the company since 1951, where he has served as sales representative with the Philadelphia district office, southern regional sales manager, and New York sales manager. Previously, he was associated with Williams, Brown and Earle Co. in Philadelphia, as assistant sales manager of laboratory chemicals.

GENERAL ELECTRIC

Frederick J. Burnett has been named manager, alkyd resin product sales, in the chemical materials department, according to an announcement by James W. Raynolds, marketing manager.


F. J. Burnett

Mr. Burnett joined General Electric in 1951 as technical service supervisor in its chemical materials department, after 15 years of experience in development, purchasing and sales areas of The Egyptian Lacquer Manufacturing Co., South Kearny, N. J. In 1953 he was named supervisor of sales and product planning for paint and alkyd resins—a position he held until his present appointment. In his new assignment, Mr. Burnett will continue to be located at his present chemical materials department address: 77 River Road, Schenectady, N. Y.

REICHHOLD CHEMICALS

Don Leever has rejoined the company after three years to become its division director of technical service in St. Louis, St. Paul, Kansas City, Denver, Houston and Dallas.

Mr. Leever was first with the Berry Brothers Paint and Varnish Co. in Detroit in 1934. Three years later he transferred to the Acme White Lead and Color Works in the same city and, in 1940, went to Ferro Enamel Corporation's liquid plastics division.

In 1942 he joined RCI as a formulator in the technical service laboratories in Ferndale, Mich., being made director of technical service there a year later. In 1951 he also assumed the duties of district sales manager. In March, 1952, Mr. Leever became assistant sales manager of the Surface Coating Resin Division and, in September, 1953, left for Wichita, Kan., to run the plant and laboratories of the Kansas Paint and Color Co. where he remained until returning to RCI at this time.

SINCLAIR REFINING

Robert J. McAuliffe has been appointed manager, Southwestern Division, Paint Department, with headquarters at Houston. He has been foreman of the Paint Sales Service Unit at Houston, and assistant to John F. Younger deceased, whom he succeeds.

In his new position, Mr. McAuliffe will be in charge of paint operations and sales service in the region served by the Southwestern Division of the Paint Department.

EMERY INDUSTRIES

Robert F. Connelly has been assigned as the West Coast field salesman for the organic chemical sales department, according to R. F. Brown, organic chemical sales manager.


R. F. Connelly

Mr. Connelly will be responsible for sales of all organic chemicals including plasticizers, dibasic acids, synthetic lubricant bases, textile chemicals, soluble oil bases, and special derivatives.

Prior to joining Emery, he was associated with the Bray Oil Co. in a research and development capacity, and the Shell Oil Co. in a similar capacity.

Robert J. Sturwold and **E. B. Cook, Jr.** are recent additions to the research staff, according to Dr. R. G. Kadesch, director of research.

Mr. Sturwold has joined the organic research section under the supervision of C. G. Goebel.

Mr. Cook is associated with the process research section under the direction of V. J. Mucherheide where he will conduct research on dry cleaning processes for the Sanitone division. He was formerly manager of the Colonial Cleaners, Inc., in Atlanta, Ga.

ARCHER-DANIELS-MIDLAND

Don C. Hawkins, Jr., has been appointed sales representative for the New York sales office, it has been announced by Paul McClay, assistant vice president in charge of sales for the company's New York office and six Atlantic seaboard states.

Mr. Hawkins will represent soybean and linseed oil meals, soy specialty proteins and industrial cereal products in the eastern sales territory. He has been with ADM since 1948, working at the firm's Minneapolis office. He held positions in inventory control, contracts and oil shipping departments until 1951 when he was transferred to the soy specialty products division.

Two additions to the advertising staff have been announced by Gene Fowler, advertising manager. **Edward H. Devoy** and **Harold H. Lee** will concentrate their efforts on the firm's formula feed and feed ingredient advertising.

Mr. Devoy was a partner in the Dwyer & Devoy advertising agency for nine years before joining ADM. Previously, he was account executive and merchandising manager for Knox Reeves Advertising, Inc., Minneapolis.

Prior to joining ADM, Mr. Lee was assistant advertising manager for the J. R. Watkins Co., Winona, Minn., working with a variety of products, including feed supplements.

REARDON

Harry E. Davis, Jr., has been elected to the newly-created position of executive vice president, it has been announced by David H. Moran, president.

Mr. Davis joined the company in 1947, was promoted to advertising and sales promotion manager in 1948, and elected to the firm's board of directors a year later. In 1951 he was named assistant to the president, and was elected a vice president in 1952.

Long active in paint industry affairs, Mr. Davis has served on a number of committees of the National Paint, Varnish and Lacquer Association, and is currently vice chairman of that group's Industry Education, as well as president of the St. Louis Paint, Varnish and Lacquer Association.

UNITED WALLPAPER

Howard N. Wedelstaedt has joined the company as assistant to the vice president of operations. The department handles all central purchasing for United's paint and wallpaper factories.

Mr. Wedelstaedt started with Sears Roebuck in 1951, where he filled a variety of training assignments. He was transferred to the Sears paint and wallpaper factories at the time of its consolidation with United.

REICHHOLD CHEMICALS

W. A. "Art" Weismann has joined the company as regional sales manager for resins for surface coatings, according to an announcement made by P. L. Swisher, vice president and director of sales and advertising.

NOPCO

Dr. John E. Ward has been named to a newly created research post with the company and will be responsible for the development of product research programs with established goals for all its industrial divisions.

J. E. Ward

The ultimate goal will be new and improved industrial processing chemicals for such industries as paint and varnish, pulp and paper, textiles, leather and tanning, cosmetics, plastics, detergents, construction materials, and a host of others. Dr. Ward's initial project will be to develop such a program for the paper chemicals division. His former position as head of the paper chemicals laboratory has been assigned to **R. B. Porter.**

DEWY and ALMY

William Morton has been promoted to Midwest regional sales manager of organic chemicals, it was announced by Charles E. Brookes, sales manager, organic chemicals. He replaces **John G. Broughton** who has moved to the Eastern region as sales manager.

Wm. Morton

Mr. Morton joined the company in 1955 working the Southwest territory out of Houston. He had previously been employed by the J. T. Baker Chemical Co. of Phillipsburg, N. J.

At the same time, Mr. Brookes announced the assignment of **Floyd E. Witzel** to the Midwest territory. He replaces **Charles Neunhoffer** who has been transferred to Houston. Mr. Witzel comes to Dewey and Almy from Freeman Chemical Co. of Milwaukee, Wis. Before that, he was associated with Pittsburgh Plate Glass Co. where he did paint formulation and customer service work. He will work out of the Chicago office.

EMERY INDUSTRIES

Dr. Norman O. V. Sonntag has been appointed to the research staff, it was announced by R. C. Kadesch, director of research.

Dr. Sonntag will be connected with the process research section under the direction of V. J. Muckerheide where he will be in charge of research in the fast growing field of synthetic lubricants for jet and gas turbine engines. He formerly was chief chemist for the chemical division of the Celanese Corporation of America.

EVANS RESEARCH

Dr. Everett G. McDonough has been elected executive vice president, it was announced by Dr. Ralph L. Evans, president of the chemical consulting firm. In announcing the creation of this new executive position, Dr. Evans pointed out that recent expansions of the staff, facilities, and activities have created new responsibilities within the consulting organization.

Dr. McDonough has been vice president and general manager of the organization. He is also a director, and chairman of the executive committee. He has been associated with the Marinello Corp., and Inecto, Inc., and is now vice president of Evans Chemetics, Inc.

COLUMBIAN CARBON

Donn Snyder has joined the carbon black and pigment division and will make his headquarters in the company's sales office in the Park Square Building, Boston. He will serve carbon black and pigment users in New England.

D. Snyder

Mr. Snyder is a native of Plainfield, N. J., and a graduate of Princeton University with a bachelor's degree in chemical engineering. He also holds the degree of MBA from Harvard Business School. He comes to Columbian from three years with Goodyear Tire & Rubber Co. at Akron, Ohio.

E. B. Dunning

R. E. Fiedler

ARCHER-DANIELS-MIDLAND

Raymond E. Fiedler and **Edward B. Dunning** have joined the development department, it was announced by Dr. George K. Nelson, department director.

Mr. Fiedler has been appointed manager of agricultural products development, activities directed at expanding the company's interest in products related to the agricultural industry.

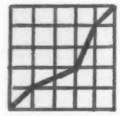
Mr. Dunning has been assigned to the industrial chemical development group, which at present is working to evaluate new ADM chemicals, including derivatives of fatty alcohols and other materials, and possible markets for them.

Before joining ADM, Mr. Fiedler was senior chemical engineer at the Staley Manufacturing Co., Decatur, Ill., where he worked for 14 years. Prior to that he was sales engineer for the Swenson Evaporator Co., Harvey, Ill., and development engineer at the Reilly Tar and Chemical Co., Indianapolis, Ind.

Mr. Dunning has been with ADM since 1954 as a research chemist, working at the firm's Minneapolis research laboratory. Previously he was an instructor and research fellow at Purdue University while completing work for his doctorate degree in organic chemistry.

The transfer of **Walter Thulin** from the development department to the staff of the Applied Radiation Corp. (ARCO), an affiliate of ADM, has also been announced by Dr. Nelson.

His duties there will consist primarily of market development and merchandising in connection with the electronic accelerator. As an orientation to his new duties, he recently attended a "Nuclear Engineering Short Course" at the University of California. Since joining ADM last year, Mr. Thulin has been a member of the firm's development department. Previously he held the position of supervisor of new product development for a Minneapolis milling firm.



SPENCER KELLOGG

John B. Pierce has been appointed sales representative in the New York territory. He started with the company in 1940 in the accounting department where he remained until his entry into the U.S. Marine Corps in 1942 serving four years. Following his discharge, Mr. Pierce returned to the administrative offices and was assigned to duties in the castor oil department. In 1947 he was transferred to the Baltimore office as sales representative and remained there until his recent transfer to the New York office.

J. B. Pierce

Mr. Pierce is a past president of the Baltimore Paint Salesman's Club, past Southern Zone vice president of the National Paint Salesmen's Association and past secretary of the Baltimore Paint, Varnish and Lacquer Association.

WITCO CHEMICAL

George F. Polzer has been appointed to the newly created position of purchasing director, it was announced by Max A. Minnig, president. He will direct all purchasing activities of Witco, and coordinate the purchasing of Witco Associated companies.

Mr. Polzer, will be located in the executive offices of the company of 122 E. 42 St., New York. He formerly was general purchasing agent for chemical raw materials with American Cyanamid Co., and previously assistant to the manager of purchases for The Texas Co. He also has worked in production and research, to establish background experience for his purchasing activities. He is a co-founder of Racemics, a well-known chemical industry organization composed equally of sales and purchasing personnel.

GLIDDEN

George M. Halsey has been elected vice president in charge of the Chemicals-Pigments-Metals Division, it was announced by Dwight P. Joyce, chairman and president.

Mr. Halsey, 45, succeeds **John P. Ruth,** who is retiring after 29 years service with the company. Mr. Ruth will continue as a director of the company, a member of the executive committee, and as a consultant.

The new Glidden vice president started his career with the firm in 1933, as a draftsman at the St. Helena plant in Baltimore. He advanced successively through assignments as shift foreman and plant engineer before being named St. Helena plant manager in 1946.

He has been director of manufacturing for the Chemicals-Pigments-Metals Division since 1950.

In his most recent capacity, Mr. Halsey has been in charge of engineering for and construction of the company's new $8,000,000 Adrian D. Joyce Works at Baltimore. He will now direct the $20,000,000 expansion of the new plant, which recently commenced operations, to quadruple its present capacity.

Mr. Ruth joined the company in 1927 as chief chemist at the Collinsville, Ill. plant, was named general manager of the Chemicals-Pigments-Metals Division in 1945, was elected a director and vice president of the company in 1947, and since 1951 has been a member of the executive committee.

COLTON CHEMICAL

Ernest J. Hill has been appointed sales manager of Colton Chemical Co., Division of Air Reduction Company, Inc., it was announced by Bernard R. Krashin, president.


E. J. Hill

Mr. Hill, formerly assistant sales manager, has spent a number of years in product sales to the paint, plastic, chemical, rubber and adhesive industries. He has also held managerial sales positions with Ferro Chemical Co., Cleveland, and the chemical division of Goodyear Tire and Rubber Co. In his new capacity, he will be in charge of sales representatives and agents for the expanding line of company products.

ARMOUR & CO.

Burton W. Graham has been appointed sales director of the chemical division, a position formerly held by **J. M. Hoerner,** division general manager.


B. W. Graham

Mr. Graham received a Master of Science degree from the University of Florida in 1937. Following several years sales experience in the chemical field, he joined Davison Chemical Division of W. R. Grace & Co. in 1944.

Since that time he has been product sales manager, assistant general sales manager of industrial chemicals, director of technical service, and director of commercial chemical development for Davison.

JAMES BUTE

Travis R. Coulter has been appointed general sales manager, it was announced by Loren B. Odell, president. He has served in various managerial capacities in the Southwest for many years and is well known for his experience in both the retail and wholesale marketing of paints and allied products. **Harold N. McCann,** trade sales manager, will assist Mr. Coulter by working with Bute dealers and heading up the sales development and advertising of the company.

SHAWINIGAN RESINS

Joseph G. Martins, who has been conducting research in organic chemistry for the past five years, has joined the research department. He is now a member of the company's "Gelvatol," polyvinyl alcohol, research group.

INDUSTRIAL PAINT

Ernest C. MacDonald has been appointed technical director, according to an announcement by William E. Hood, president. From 1946 until 1950 he was with DeVoe and Raynolds in Louisville, and from 1950 to 1952 he served as chief of the paint and varnish division of Eagle Picher. From 1952 to 1956, Mr. MacDonald was technical service director of the Georgia Marble Co., paint pigments division.

E. C. MacDonald

Also added to the staff as chemist was **Robert Copus,** who has been with Goodyear Tire and Rubber Co. and Industrial Paint Manufacturing Co.

ARMOUR RESEARCH

Arthur G. Dreis has been appointed assistant manager of the chemistry and chemical engineering research department at Armour Research Foundation of Illinois Institute of Technology, Chicago.

Clark E. Thorp, department manager, reported that Mr. Dreis will coordinate the work of the fine particles, organic and polymer, physical chemistry, and chemical engineering research sections.

Mr. Dreis was senior technical sales engineer for the Hercules Powder Co. from 1937 to 1951, director of the new paper development department for the P. H. Glatfelter Co. from 1951 to 1954, and for the last two years did consulting in paper products.

He joined the Foundation in November of 1955 as a technical consultant in chemistry and chemical engineering research. A recognized authority on problems relating to paper manufacturing and development of coatings for paper products, he also has worked with paints, wax and resin emulsions, adhesives, cosmetics, and graphic arts problems.

SPENCER KELLOGG

Marko Markoff has joined the company's Research Center as a research chemist in the application research section, it was announced by Dr. Malcolm Renfrew, director of research and development.

Mr. Markoff was formerly employed by the American Marrietta Co. as chief chemist, physical testing and specification laboratory.

MARBON CHEMICAL

Walter H. Kuhlen has been appointed technical sales representative for the company's Pennsylvania, New York and Southern Area territory, it was announced by D. M. Pratt, vice president and sales manager.

W. H. Kuhlen

After serving two years in the U. S. Coast Guard, Mr. Kuhlen worked as a sales engineer for Timken Automatic while attending Northeastern University in Boston, Mass. Prior to receiving his B.S. degree in Business Administration, he had two years of mechanical engineering experience. Mr. Kuhlen has completed two years of technical training at the Marbon Chemical plant in Gary, Ind.

INLAND STEEL

Robert J. Greenebaum has been promoted to president of the drum and pail fabricating division. He has been vice president in charge of sales in which position he is succeeded by **J. Daniel Ray,** general sales service manager of Inland Steel Products company of Milwaukee, Wis., subsidiary of Inland Steel Co.

Mr. Greenebaum joined the container division in 1939 before it was taken over by Inland. He has been promoted through successive jobs in sales from salesman to sales vice president and served one year in production as plant manager of the division's Chicago plant.

Mr. Ray moves to Inland Steel Container Co. after eight years with Inland Steel Products Co. where he has served as staff assistant to the president, manager of the Baltimore plant, assistant general manager of sales and general sales service manager.

DOW CHEMICAL

Manson C. Carpenter has been promoted to head of technical service and development activities for latex paints, it has been announced by N. R. Peterson, manager of coatings technical service. He has been in charge of development work on coating materials for textiles since 1953.

In his new position, Mr. Carpenter will not only supervise work on interior latex paints but be responsible for new developments in exterior paints and also industrial paints based on Dow latexes. He succeeds **Fred K. Quigley, Jr.,** who has been advanced to the post of assistant manager of coatings technical service with increased responsibilities in handling Dow's work on coatings in the paint, paper, textile and other fields.

Mr. Carpenter joined Dow in 1949. He started in the textile section of coatings technical service in 1950 and also served in the evaluation section where he assisted in supervising the evaluation of promising new coating materials.

Mr. Quigley came to the company in 1946 working on organic synthesis for a year. He joined coatings technical service in 1947, the year it was formed. From 1948 to 1953 he was head of Dow's technical service and development work with the textile industry.

Charles W. Cairns and **H. Winston Haskell** have been appointed assistants to the manager of coatings sales, it has been announced by D. L. Gibb, sales manager of the plastics department.

Mr. Cairns has been associated with coatings sales in the Detroit office since 1949. Mr. Haskell has been a Dow employee since 1953.

Three others who recently completed sales training programs have been added to the staff of field salesmen handling coating products. **Martin A. Craig** replaces Mr. Cairns in Detroit and **Robert C. Witt** and **Robert H. Moberg** have been assigned to the Chicago and Buffalo offices, respectively.

CARBIDE and CARBON

Fourteen new salesmen have joined the company. They are: **L. R. Graham** from Purdue University; **G. O. Fishburn** from Colgate University; **R. C. Muller,** Iowa State College; **H. M. Jones, Jr.,** Rose Polytechnic Institute; **J. W. Demaree,** Purdue University; **E. P. Cass,** Northeastern University; **H. R. Hubbs,** Stanford University; **T. J. Kuzara,** Colorado School of Mines; **N. J. Hill,** Lebanon Valley College; **A. M. Chagares,** Colgate University; **A. V. D'Amelia,** University of Massachusetts; **G. W. Shoemaker,** University of Mississippi; **W. C. Friedemann,** University of Tulsa, and **A. G. Breckling,** Ohio Wesleyan University.

ASP ALUMINUM SILICATE PIGMENTS

UNIQUE EXTENDER PIGMENTS THAT IMPROVE YOUR PRODUCTS

Edgar ASP 400 (most widely used extender pigment in latex systems) is a profit-building "natural" in fast-selling PVA paints too!

An Asset In Your Plant—This easy-to-use material will help you cut manufacturing costs. Rely on it for chemical compatibility, ideal physical uniformity, viscosity stability, easy dispersion—a work and worry saver in just about every formulation step.

An Even Greater Asset In The Marketplace—Your customers (and *their* customers) will be glad to know how "made with ASP 400" interior paints will perform. "Built-in" anti-settling features mean no hard caking-in; excellent leveling and flow characteristics mean smooth, ghost-free finishes; the absence of water-sensitive chemicals means no water-spotting. It all adds up to clean, clear superiority for your product in the hands of decorator, or "do-it-yourself."

You Always Get More Than ASP 400—To the trade, M & C and Edgar mean more than Extender Pigments . . . they mean *reliable* recommendations . . . extensive and informative technical data . . . generous test samples. Any or all for the asking. Use the coupon.

EDGAR PRODUCTS *from . . .*

MINERALS & CHEMICALS CORPORATION OF AMERICA

34 ESSEX TURNPIKE, MENLO PARK, N.J.

SERVING OVER 1000 PAINT MANUFACTURERS FROM WAREHOUSE STOCKS IN 30 CITIES

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Please send me:

- ☐ Complete, up-to-date technical literature
- ☐ Sample drum of ASP product(s) for use in

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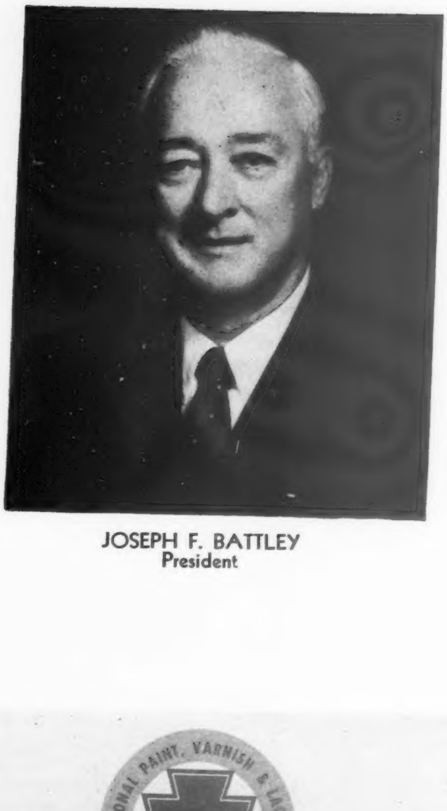
National Paint, Varnish

and Lacquer Association

68th Annual Convention

LEO S. GUTHMAN
Vice-President



JOSEPH F. BATTLEY
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NATIONAL PAINT, VARNISH & LACQUER ASSOCIATION, INC.
PROGRESS THROUGH COOPERATION

DAVID H. MORAN
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NEWS

Management Forums to Feature NPVLA Meet.

The management forums, so successful in the past will be repeated at the forthcoming 29th annual convention of the National Paint, Varnish, and Lacquer Association in Los Angeles, November 12-14th.

Trade Sales and Industrial Product Manufacturers will hold their special sessions, Tuesday afternoon, Nov. 13th. Roof Coating manufacturers will hold their forum, Monday afternoon, Nov. 12th and Putty and Caulking producers on Tuesday, Nov. 13th. The forum for Advertising and Sales Promotion is scheduled for Mon., Nov. 12.

The luncheon and management panel for industrial product finishes management personnel will include a selected group of leading authorities in major industries using finishes. They are: R. J. Wirshing of the Chemistry Dept. of General Motors who will talk about Automotive finishes; G. M. Hill of Drexel Furniture Co. who will discuss furniture finishes; E. L. Faneuf of Whirlpool Seeger Corp. who will take up appliance finishes, and W. W. Sacks of the E. F. Hauserman Co. who will talk about metal finishes in general.

These panel members will be chiefly concerned with the limitation of finishes on their respective products, new properties these finishes should have, how finishes are evaluated, who determines the proper finish to be used, and how suppliers can improve their services.

Again by popular demand, conventioneers will hear Leo M. Cherne, executive director of Research Institute of America, give his opinion on what lies ahead as a result of this year's National Elections.

Another feature of this convention will be a talk on "Dynamic Selling" by Donald C. Sloan, president of Donald C. Sloan and Co. Mr. Sloan has gained world wide recognition as an authority in the practical application of "dynamic selling."

In addition to the business sessions, a series of interesting social events for the ladies have been arranged.

Harshaw Expands Overseas Manufacturing Operations

The Harshaw Chemical Co. of Cleveland, Ohio has established a wholly-owned English subsidiary, Harshaw Chemicals Ltd., with offices, manufacturing plant and laboratories at Waltham Cross, London.

The new unit was formed primarily to supply electroplating chemicals and processes for the British Isles. Other chemicals manufactured by the parent company are expected to be added as markets are developed.

A. C. Benning, long active in the manufacture, sale and service of electroplating chemicals at the home office has been appointed manager of the new unit, and S. E. Pross, Hounslow, has been named assistant general manager. Among Mr. Pross' former connections was a tour of duty for the Kuwait Oil Co. in the Persian Gulf area.

Harshaw electroplating chemicals have been available in England through agents of L. van der Hoorn's Chemische-Technische Industrie, N.V. who have been operating under license at Utrecht for several years. The new unit will supplant these imports.

Reichhold, Cyanamid In Melamine Resin Pact

Reichhold Chemicals, Inc., will manufacture melamine resins for the surface coating, adhesive and laminating industries under a license agreement with American Cyanamid Co., it was recently announced.

Initially, manufacture of the new RCI products will be conducted at the firm's Elizabeth, N.J.; Detroit and San Francisco plants. It is expected that expanded production will be undertaken at additional RCI plants at a later date.

Manufacture of melamine resins will open to RCI a number of additional markets in the three fields—coatings, adhesives and laminates—since the new and special properties of melamine will enable it to supplement some existing products and improve others.

IN OPERATION: Union Bag & Paper Corp. has announced that its new $2,500,000 tall oil distillation plant in Savannah, Ga. has recently started commercial production. The new plant will manufacture distilled tall oil, tall oil rosin, tall oil fatty acids and tall oil pitch.

Discuss Latest Advances In War Against Corrosion

Latest advancements in industry's constant war against corrosion were discussed Sept. 12 by Dr. Frank J. Honn, head of the applications laboratory of The M. W. Kellogg Co., Jersey City, before the New York section of the National Association of Corrosion Engineers.

Many of today's processes demand high temperatures and unusually corrosive chemicals, making corrosion more likely unless proper precautions are taken, Dr. Honn said. Corrosion leads to equipment failure, excessive down-time and product contamination, he asserted.

Dr. Honn discussed in detail the organic finishes approach to corrosion control, and cited results obtained with the fluorocarbon resins, elastomers, oils, waxes, greases and laminates.

Cellofilm Announces Plans

Cellofilm Industries, Inc., Woodridge, N. J., has announced that it is now entirely divorced from the motion picture industry and is using nitrocellulous solutions for base lacquers. The company also plans to manufacture a vinyl solution in the near future.

The author continues his random reflections on various aspects of the paint industry. The opinions expressed in this column are his alone and do not necessarily reflect those of this publication.

Creativity in Research

FOR years "classified knowledge gained and verified by exact observation and correct thinking" has been accepted pretty unquestionably as the standard definition of science. A rather colorless definition, I'll concede, but undeniably dignified.

Now the heretical *Readers Digest* upsets our apple cart by quoting the wag who calls science just "an orderly arrangement of what at the moment seems to be facts." This should be grounds for an argument, but, since science by any other definition would challenge as relentlessly, we won't quibble.

Anyway we look at it, science is built upon facts, no matter how obtained. Too often, as we all know, the experimental approach alone is inadequate. Basic discoveries arise with alarming frequencies from those unaccountable "hunches" or "accidental" observations that fall outside the orderly and preictable routine of scientific research. This production of new facts without a complete dependency on pre-existant material is termed creativity. And it is this creativity which is the lifeblood of research.

Phil Heiberger

What is this elusive facility called creativity? Can creative thinking be taught? If so, how?

The American Management Association Special Report No. **6**, *"Getting the Most from Product Research and Development"* and *Alex F. Osborn's book, "Applied Imagination"* offer some provocative answers.

Creativity Defined

Jules D. Porsche, Manager of the Central Research Department, Research Division, Armour and Company, says in the AMA report, that creative ability "is the faculty possessed by human beings for integrating facts, or impressions, or feelings resulting from experience into a new form. It is the ability to establish new connections between facts or symbols. It is a capacity for gaining new insight into the relations between bits of existing knowledge. . . .

"The creative person perceives the possibility of combining products of his own intellectual or emotional experiences into something new. He feels impelled to do this. The actual process occurs during or after a period of incubation at the subconscious levels of the mind.

"In many respects, this phase of creative thinking resembles a dream. . . .

"After this unordered or illogical creative process of integrating impressions, facts, and feelings into new structures, the logical, rational, and intellectural faculties take over and critically examine this creation. . . .

"The result. . . .must be either acceptable or tenable at the time the creative act is performed or at some time thereafter."

Research on Research

The appreciation of and interest in creativity in research have reached such dizzying heights in

recent years that now research is being carried out on the subject of research itself. That is, there has been a concerted effort by psychologists and management personnel to understand more completely the phenomena of creative activity.

Industrial psychologists who have studied the process of research, the mechanism of creativity, and the personality of the creative man, have come up with some surprising and fascinating analyses. Porsche points out, incidentally, that creative activity is not confined to the research department, that many ideas for new products and new processes originate outside of research.

Psychologicalstudieshaveshown, he says, that "the more creative scientists in industrial research are self-sufficient, self-reliant, self-confident. They work at a high energy level. They are career-oriented. They identify strongly with their companies."

Thorn in the Flesh

"The creative person is a restless type of individual with certain unsatisfied emotional needs. We never see the complacent, self-satisfied emotional needs. We never see the complacent, self-satisfied individual coming up with a new and revolutionary idea. . . . (The) creative person has a 'thorn in the flesh.'. . . .

"The compelling force or urgency which drives the creative worker must not be confused with anxiety or fear. The 'thorn in the flesh' produces a positive or an offensive attitude in contrast to the defensive attitude characteristic of the anxious or fearful person. This defensive attitude is incompatible with effective creative work."

While it is evidently true that imagination and creative ability are God-given talents which exist in each individual in varying degree of quantity and quality, it is also true that these talents can be easily stifled by maturity, education, and experience.

Conversely, it is now recognized that these talents can be encouraged, nurtured, stimulated—in fact, say the psychologists, they can actually be taught.

Says Osborn, "certain attitudes favor the production of ideas, while other attitudes adversely affect ideation." A negative reaction toward a strange problem or a new idea can have a devastating effect. "*Dr. L. L. Thurstone* pointed out that almost any proposed idea can be shown to be wrong, immediately and logically. Sometimes the proof is so convincing that one is tempted to discard further thought about the new proposal."

Judicial Mind Vs. Creative Mind

Osborn continues, "Our thinking mind is mainly two-fold: a judicial mind which analyzes, compares, and chooses. A creative mind which visualizes, foresees, and generates ideas. Judgement can help keep imagination on the track, and imagination can help enlighten judgement.

"Judicial effort and creative effort are alike in that both call for analysis and synthesis. . . .(but) judgement tends to confine itself to facts in hand, (while) imagination has to reach out for the unknown. . . .

"In the average person, judgement grows automatically with years, while creativity dwindles unless consciously kept up. Then, too, education strengthens our judgement. Over 90% of our schooling tends to train our judicial faculties.

". . . .The right mood for judicial

thinking is largely negative. In contrast, our creative thinking calls for a positive attitude. . . .

". . . .In creative effort, we have to play Jekyll-and-Hyde. From time to time; we must turn off our judicial mind and light up our creative mind. . . .Premature judgement may douse our creative flames and even wash away ideas already generated."

Group Brainstorming

Analysis and recognition of the various factors involved in imaginative and creative thinking has led to the development of "brainstorming" techniques which involve the use of groups in creative activities to expedite product development and stimulate creativity in other phases of business.

Says Porsche, in the AMA report, "One value of a group in creative work lies in maintaining a certain degree of tension or pressure. The tension generated intensifies concentration on the problem and increases the frequency of imaginative leaps. In group work it is possible to lower censorship barriers by persuading the members to postpone critical judgement while thinking up and expressing new ideas. Mutual reinforcement by members of the group aid in releasing the brakes on the imaginations of the individuals. The net result is a greater volume of ideas for critical review."

In another chapter of the AMA report, *Arthur C. Studt, Manager of Education and Training of the Hotpoint Company*, describes methods of developing professional and managerial talent with "how to think" programs. Included in this chapter is some fascinating material taken directly from the instructor's manual for the Hotpoint Company's "Creative Thinking" course. This course utilizes the "group brainstorming" technique. If you're in the mood for some stimulting mental exercise and some fun, I recommend that you take a peek at this. If you're not, look at it anyway. I guarantee that five minutes later you'll be in the mood.

How to Encourage Creativity

Porsche believes that only in the ideal environment can even a gifted individual make "successful, long-range, imaginative leaps." He lists a few rules of thumb which have proved useful to him:

1. Creative work is always given spontaneously. It cannot be extracted.

2. The creative worker must be made secure and encouraged to develop self-confidence to the maximum.

3. The creative worker must have an adequate background of factual knowledge in his field of work. He must also be thoroughly familiar with the policy framework within which he can operate.

4. The creative thinker must be free to communicate with those having useful knowledge, points of view, and ideas.

5. Warm, encouraging acceptance on the part of the supervisor always stimulates creative output.

6. Some guidance must be supplied in the form of constructive criticism. Many creative people need the reassurance of gentle tension on the reins.

7. A feeling of urgency on the part of the administrator is perceived by the researcher and will be imitated. Urgency must not be confused with anxiety.

8. Competitive drives can be utilized to create tension or a feeling of urgency. This technique is well adapted to use in group situations. Excessive competition, however, has a negative effect.

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PATENTS

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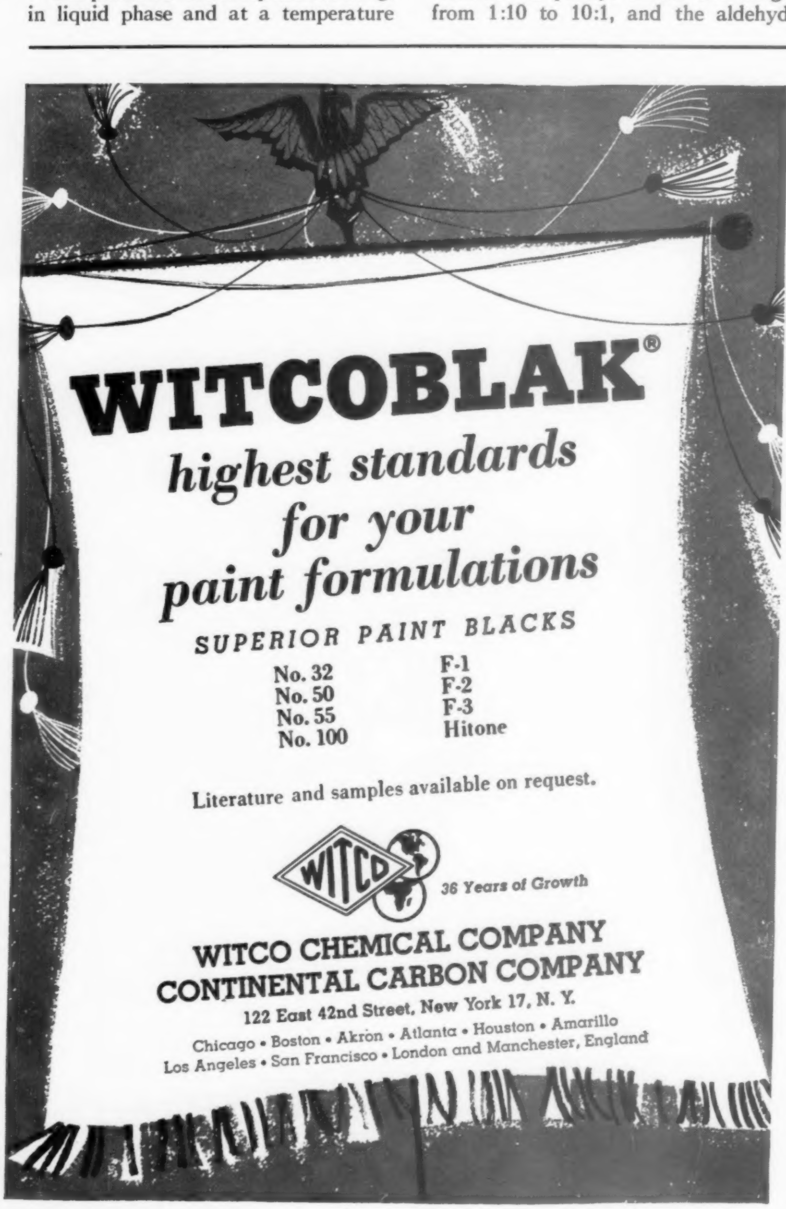
Phenol-Aldehyde Type Organosilicon Resins

U. S. Patent 2,755,269. Kenneth W. Moorhead, Midland, Mich., assignor to Dow Corning Corporation, Midland, Mich., a corporation of Mich.

The process which comprises reacting, in liquid phase and at a temperature of at least 50° C., an aldehyde with the reaction product of (1) an organosilicon compound of the average general formula $R_nSiY_aO_{(4-n-a)/2}$ where R is a monovalent hydrocarbon radical free of aliphatic unsaturation, n has an average value of from 1 to 3 inclusive, Y is a substituent selected from the group consisting of alkoxy radicals, chlorine, and bromine, and a has an average value of from 0.2 to 3 inclusive, the sum of $n+a$ being not greater than 4, with (2) an hydroxyphenyl compound selected from the group consisting of resorcinol, p,p'-bis-hydroxyphenyldimethylmethane, phenol, cresylic acid, monoalkyl substituted phenol, and monoaryl substituted phenol, (1) and (2) being employed in an amount such that the ratio of silicon linked Y substituents to phenyl linked OH ranges from 1:10 to 10:1, and the aldehyde being employed in amount such that the molar ratio of adlehyde tohydroxypheny compound ranges from 0.1:1 to 6:1.



Emulsions of Ionically Cross-Linked Resins

U. S. Patent 2,754,280. George L. Brown, Moorestown, N. J., and Benjamin B. Kine, Levittown, Pa., assignors to Rohm & Haas Company, Philadelphia, Pa., a corporation of Delaware.

As a new composition of matter, an aqueous medium comprising dispersed therein (1) a non-ionic emulsifier, (2) a water-insoluble copolymer containing, in the polymer molecule, units of at least one ester of an acid selected from the group consisting of acrylic and methacrylic acids and 0.25 to 25 molar percent of carboxyl-containing monomeric units derived from at least one member of the class consisting of acrylic, methacrylic, and itaconic acids, and (3) a basic metallic compound, in an amount from 0.125 to 12.5 molar percent based on the weight of the copolymer, selected from the class consisting of polyvalent metal salts of weak acids, basic salts of polyvalent metals, the oxides and hydroxides of barium, calcium, magnesium, and strontium, and the hydroxides of aluminum, lead, and zirconium.

Low Viscosity Ethyl Cellulose Phthalate

U. S. Patent 2,753,339. Carl J. Malm and Carlton L. Crane, Rochester, N. Y., assignors to Eastman Kodak Company, Rochester, N. Y., a corporation of New Jersey.

The process for preparing low viscosity dicarboxylic acid esters of ethyl cellulose which comprises treating ethyl cellulose in solution in acetic acid with .1-10 parts of sulfuric acid per 100 parts of ethyl cellulose and subsequently adding to the mass an acid soluble acetate salt which exhibits basic properties in non-aqueous aliphatic acid solution in an amount of 5-150 parts which will promote esterification with a dicarboxylic acid anhydride and esterifying the ethyl cellulose with a dicarboxylic acid anhydride, the salt added acting as a catalyst for the esterification reaction.

Lacquer Plasticizer

U. S. Patent 2,754,306. Louis I. Hansen, Minneapolis, Minn., assignor to Archer-Daniels-Midland Company, Minneapolis, Minn., a corporation of Delaware.

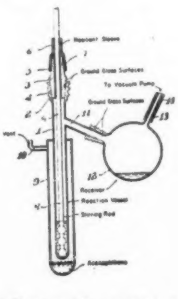
A method of making a plasticizer for nitrocellulose and like compositions comprising a blown dialkyl ester of a maleinized drying oil which method comprises the steps of forming a dialkyl ester of a maleinized drying oil by reacting a drying oil, an aliphatic alco-

hol having from 1 to 13 carbon atoms and a compound selected from the group consisting of alpha-beta ethylenic dicarboxylic acids and anhydrides, said ester having an acid value not greater than about 3, and blowing the ester with an oxidizing gas at a temperature of from about 150° to 220° F. until the blown ester becomes light in color.

Preparation Of Polyalkylene Terephthalates

U. S. Patent 2,758,105. Francis Peter Alles, Westfield, and William Russell Saner, Plainfield, N. J., assignor to E. I. du Pont de Nemours & Co., Wilmington, Del., a corporation of Delaware.

In a process for the preparation of a highly polymeric polyalkylene terephthalate from a glycol of the formula $HO(CH_2)_nOH$ where n is 2 to 10 and a compound taken from the group consisting of terephthalic acid and ester-forming derivatives thereof, to form a polyalkylene terephthalate of molecular weight between 23,300 and 33,500, in the presence of an esterification catalyst the step which comprises incorporating with said reactants prior to completion of the esterification reaction, monomeric ester taken from the group consisting of alkyl β-naphthoates and 2-carboalkoxy-3-hydroxy naphthalenes wherein the alkyl and alkoxy groups contain 1 to 4 carbon atoms, in such an amount that the unsubstituted naphthoyl radical of such monomeric esters



U.S. Patent No. 2,758,105

constitutes 1.34% to 0.93% by weight, respectively, of the molecular weight of the polyalkylene terephthalate, exclusive of the weight of the naphthoyl radical.

Polyvinyl Chloride Dissolved In a Cyclic Ether and an Amide

U. S. Patent 2,758,104. Robert L. Adelman, Grand Island, N. Y., assignor to E. I. du Pont de Nemours and Co., Wilmington, Del., a corporation of Delaware.

A composition of matter comprising a solution of a high molecular weight homopolymer of vinyl chloride in a liquid mixture of 0.6 to 19 parts by volume of tetra-hydrofuran with one part by volume of a dialkyl formamide.

Water Resistant Coating Compositions

U. S. Patent 2,760,876. Simon S. Schulman, Brooklyn, N. Y., assignor to Siliphane Corp. of America, a corporation of New York.

A substantially air-tight packaged product consisting essentially of a component for inorganic cementitious coating material, said component being a particulate solid component of coating material selected from the group consisting of titanium dioxide, barium sulphate, zinc sulphate, calcium carbonate, magnesium carbonate, yellow, red and black iron oxide, iron chromate mixtures thereof, clay and asbestos, said particles being in the order of 300 mesh and having a covering thereon completely coating the entire surface thereof, said coating being of alkyltriethoxysilane the alkyl group of said silane having from 1 to 5 carbon atoms, said silane being from 1 to 10 per cent of the weight of the particle it covers said coating being in the hydrophilic, unpolymerized state.

abstracts

Wash Primer Reactive Finishes

M. Kuehn, Farbe und Lack, vol. 61, No. 12, pp. 552-561 (Dec. 1955).

With the application of the wash primers for corrosion-protective finishes, the phosphated adhesion coating on the steel surface has one serious disadvantage—it is brittle. When subjected to sharp bending and impact demands, cracks can occur and finally the adhesion coating can peel off, carrying the cover coat with it. The object of further development work with the wash primers in the direction of producing improved finishes of this type must accordingly be to obtain a homogeneous adhesion coating, which does not show this advantage. Such a homogeneous adhesion coating must fulfill the following requirements:

1. It must bond the ferrous salt as ferrous phosphate to the iron by ion reaction and accordingly, this coating must grow into the crystal lattice of the iron metal, giving a firm bonding.
2. The primer coating which is so formed in this manner, should not be brittle but be flexible.
3. It must be chemically bonded through main or secondard valency forces with the cover coating which has to be applied over it.
4. It must act on the iron in a passivating manner and should also not act in a corrosive manner in the presence of water.
5. The lacquer solution, from which the primer adhesion coating should form with the required characteristics, after chemical or physical drying, should be able to take up small amounts of water as well as oil. It must possess a high capillary activity, in order to penetrate into the finest cracks and crevices of the iron surface and in given cases, should also be able to penetrate through thin coatings of rust which are still lying on the steel surface.

The fulfillment of these requirements indicated the choice of known organic compounds with the required properties. These materials thus need to contain an acid end group capable of salt formation and a sufficiently long hydrocarbon chain, so that with the chemical linkage of the acid end group to the metal, the alkyl chains are forced into a parallel arrangement and adhere to one another or to molecular chains of the lacquer filming agent of the cover coating by the van der Waal forces. A still better coupling of the mono-molecular ground coat with the cover coat must be actuated by main valency linkages by means of ester or amide groups or by mixed polymerization of unsaturated groups. Materials of this characterized nature occur in the free fatty acids of the drying oils and it is already known that drying oil lacquers and alkyd resins with a content of free fatty acids show an improved adhesion to aluminium and zinc.

The long-chained fatty acids are, however, too weak for full effectiveness. Stronger acids of suitable chain lengths are comprised by the paraffin sulfonic acids, and the alkylized benzole-sulfonic acids. The free acids however have a corroding effect on iron surfaces. As phosphoric acid, namely in the presence of chromate and molybdate ions, possesses a passivating effect on iron—and from experience the organic phosphonic acids and arsonic acids in which the phosphorus or arsenic atom, as the carrier of the acid characteristics,

is linked directly to the alkyl chain, are likewise strong acids—the conception arose to investigate such phosphonic acids and the quite similarly behaving arsonic acids, for their suitability for the formulation of adherent primer coatings. The surface-active characteristics of such materials, for example p-stearolamino-phenylarsonic acid, has been previously studied.

As these compounds prepared, in addition to the phosphonic acid and arsonic acid groups, contain in addition a carboxyl group linked to their fatty chain, the possibility existed to incorporate them into high-molecular materials by ester or amide-type combination, which are suitable as film-formers. Thus, these acids were incorporated to an amount of 5 per cent of the total acid content in alkyd resins, which were built up from phthalic acid, glycerine and linoleic fatty acid. A higher amount was not advisable because of the too-high softening effect. Test coatings with such an alkyd resin on steel sheets, showed after months of observation in the aggressive laboratory air, no traces of rust formation or sub-rusting.

The next step was to incorporate basic polyalcohols, obtained by the neutralization of the fatty acids of colophony with high molecular organic bases of the biguanide type, into alkyd resins, in which latter as the acid components, there were embodied fatty acids and dicarbonyl acids substituted by phosphonic acid groups. The biguanide compounds served the purpose of obtaining an alkaline passivation of the iron surface.

The Malinate Oils

By W. Heilmann, Farbe und Lack, vol. 61, No. 12, pp. 564-565, (Dec. 1955).

The chief characteristics of the malinate oils as compared with untreated oils are:

1. Considerably more rapid drying without troublesome after-tack.
2. Better light stability.
3. Better weather resistance.

In addition, the malinate oils can be cooked in a very short time to thick oils. For example, a malinate oil on a linseed oil basis, with a starting viscosity of 5 poise, can be brought in 2½ hours at a temperature of 260° C. to a viscosity of 40 poise.

From the results of numerous test series and storage tests, ti would appear that the malinate oils seem mainly suited for use in the following finish applications:

1. Malinate oils (low viscosity) in rapid-drying primer oil finishes, red lead and lead cyanamide paints (1 and 2 primer coatings) as well as rust protective paints (1 cover coat).
2. Malinate oil—thick oils in weather-resistant lacquer finishes, coating finishes, rust-protective finishes (2 cover coats) and quite particularly in oil and light enamel finish paints and oil paints with a lacquer brilliancy.

During the course of further tests, it was shown on account of their good finish-technico characteristics, these paints have manifold applicability and because of the favorable price, preference can be given to them. A small addition of hard resins (malinate resins) resin-modified phenol resins and AW2 resin is of advantage in cover lacquer finishes for increasing the brilliancy. The incorporation of the resins can (as is now usual with the normal oils) be conducted either in the cold way by the addition of resins pre-dissolved in the solvent medium (so far as it is not a question of extra hard types) or at higher temperatures by cooking at 220 - 240° C. with the oil.

The compatibility and solubility of a malinate thick-oil on a linseed oil basis when examined, show that the combination possibilities correspond to about that of a medium-viscous linseed oil-standoil. Apart from the mutual processing together with small amounts of hard resins and with alkyd resins, combinations with other lacquer filming agents appear to be less objective as the specific characteristics for the malinate oils no longer come completely to fruition.

The driers addition of the malinate oil lacquer finishes is best conducted with drier agents of the type of the special Soligen-cobalt-lead compound or again with drier combinations which contain 6.5 per cent cobalt and 2.4 per cent zirkon. With the linseed oil-malinate oils, the shortest drying times

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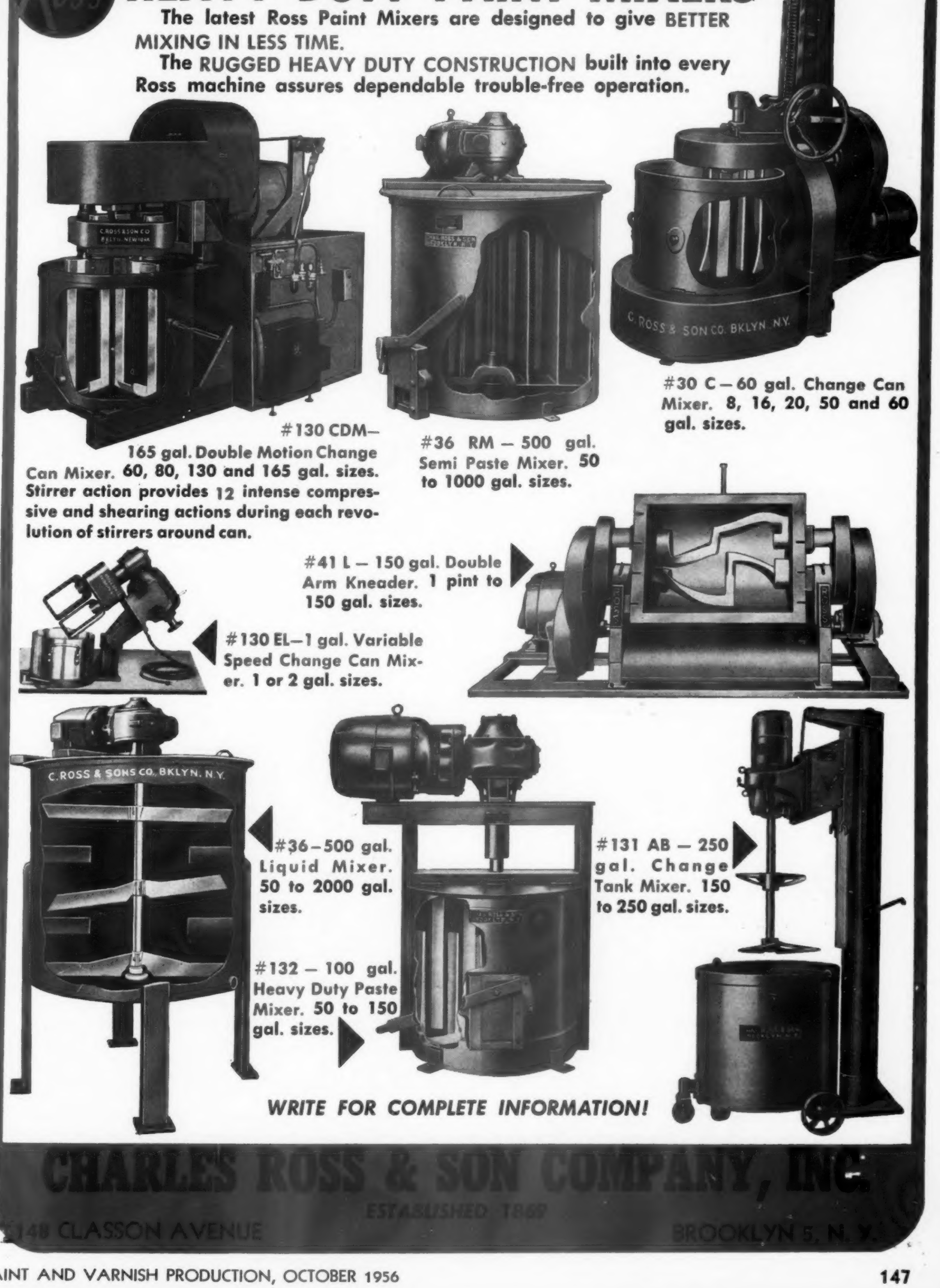
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throughout are achieved with additions of 1.2 per cent (solid naphthenate drier, calculated on oil.)

With the testing for pigment compatibility with these malinate oil finishes it was confirmed that suitably prepared malinate oils are compatible with practically all the pigments usual to the lacquer finish industry. With red lead-malinate oil finishes as well as pure zinc white or white lead finishes with malinate-thick oil, observations which were conducted over a lengthy time period failed to establish any incipient thickening over the normal degree (linseed oil-standoil paints of 90 poise). Caution and in some cases, preliminary tests, are only required with thick oils with very high viscosity. The storage stability testing for red lead finishes (German State Railway Specification—8 hours at 80° C.) showed good results with various malinate oil-red lead paint finishes. Weathering tests of these finishes in the open air, gave the following results:

1. With enamel finishes on a linseed oil-malinate thick oil basis (in various color tones): throughout there was a better color tone stability as compared with control comparison lacquering with linseed-standoil. In addition, a better stability was found against sub-rusting.
2. With white lead-malinate oil paints: there was found considerably better stability towards darkening (blackening) through the influence of industrial atmospheres.
3. With red lead-malinate oil paints: there was observed a considerably later appearance of graying and of corrosion.

As the trend of the times in the paint and finish world is for rapid drying and outstandingly stable finish lacquer filming agents, and this requirement becomes ever more prominent, it can safely be accepted that the malinate oils will continue to occupy an important position among the drying oil finishes.

The following are abstracts of papers presented at the September 16-26 meeting of the American Chemical Society, Division of Paint, Plastics, and Printing Ink Chemistry, in Atlantic City, New Jersey.

Electrostatically Applied Polychromatic Coatings

By George E. F. Brewer, Gage Products Co., Ferndale, Mich.

Frictional electrification accompanies the atomization of commercially used paint compositions when sprayed from conventional hand spray guns. In general, electrification was found to vary from positive 1 x 10^{-8} ampere to negative 1 x 10^{-8} ampere, or more. The equipment for the measurement of this electrification is described.

Electrification of the average atomized paint particle can be increased or decreased through the use of properly formulated thinners. Some examples of satisfactory thinners are given.

The electrification of paint spray was found to be correlated to the distribution of the metallic effect in electrostatically applied polychromatic paints. The metallic effect is more evenly distributed when the frictional electrification of the spray is at a minimum.

In some unusual cases the size of the frictional electrification depended upon the sequence in which the components of the thinner were added. Thus, two or more paints of identical chemical composition result in different frictional electric properties and performance. Samples of the resulting electrostatically sprayed polychromatic coatings are shown.

Chemical Interactions in Polyvinyl Formal Phenolic Resin System

By Saul M. Cohen, Robert E. Kass, and Edward Lavin, Shawinigan Resins Corp., Springfield, Mass.

To clarify the relative contributions of various chemical interactions possible in the polyvinyl formal-phenolic resin system, simplified related polymer systems were heated at moderate temperatures. The effects of acid catalyst and antioxidants were compared. Chemical interactions were detected by viscosity changes and gel formation in the final product.

The results of heating these resins generally under 200°C. for a period of

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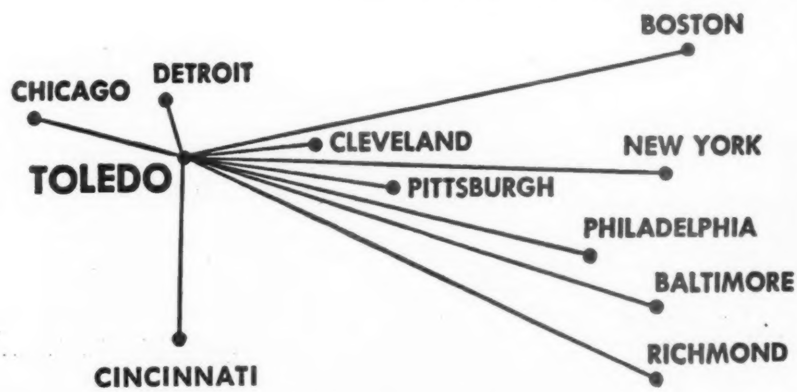

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30 minutes indicate that Formvar 15/95S (polyvinyl formal) alone does not cross-link. However, heated in the presence of phosphoric acid traces, the resin cross-links homogeneously through its hydroxyl groups. The same resin, under the same general conditions, apparently also cross-links heterogeneously with phenolic methylol groups. Finally, polyvinyl formal, heated with a phenolic methylol compound plus phosphoric acid traces, apparently undergoes some hydrolysis of acetate groups in its poly (vinyl acetate) portion.

Effect of Polyesters On Wire Enamel Properties

By M. C. Agens, R. E. Burnett, D. W. Fox, F. M. Precopio, J. W. Eustance, and J. R. Elliott, General Electric Co., Schenectady, N. Y.

The flexibility and 250° C. weight loss of magnet wire enameled with polyester solutions can be correlated with the functionality and the monomer type in glycerol-diol-phthalate resin formulations. In a series of glycerol-ethylene glycol-terephthalate resins, the effective cross linking in the cured enamel film has been determined by swelling measurements, and the relationship between potential and effective cross linking has been examined. The flexibility of the cured enamel films before and after accelerated heat aging is at a maximum for resin formulations containing 10 to 30 mole % glycerol, and falls off sharply outside this range. Initial flexibility behavior of the glycerol-free enamel is anomalous. The maximum rate of weight loss for enameled wire aged at 250°C. occurs at 10 mole % triol in the resin formulation.

The effect of diol type in a resin of fixed composition is described for a series of primary and secondary diols. Flexibility and weight loss of the cured enamel are essentially identical for enamels based on primary diols having 2 to 5 linear carbon atoms. Secondary diols reduce the flexibility rating, and have a complex effect on the weight loss. The two wire properties are essentially unchanged by the substitution of isophthalate for terephthalate units in a given resin formulation, but orthophthalate substitution results in extensive enamel decomposition during cure.

Spectroscopic Studies Of Drying Oils

By E. E. Ferguson and S. B. Crecelius, Chemistry Division, Naval Research Laboratory, Washington 25, D.C.

In a continuing investigation of the mechanisms of polymerization and degradation of drying oil films, a study of the reactions of linseed and dehydrated castor oil films exposed to ultraviolet light in the absence of oxygen has been carried out. An examination of the infrared spectra of these films has yielded the following results:

The ester groups are largely decarboxylated.

The unsaturation diminishes throughout the ultraviolet exposure, more rapidly in the case of the dehydrated castor oil than in the linseed oil.

Some of the cis double bonds isomerize to trans double bonds. No evidence for isomerization of nonconjugated to conjugated systems is observed. However, small amounts of terminal double bonds were formed in each case.

Oxidative Degradation Of Epoxy Coatings

By W. R. R. Clark and Jesse Blount, Jr., Case Institute of Technology, Cleveland, Ohio.

The effect on the oxidation rate of acid-cured Epon films of such coating variables as air-dry time, duration and severity of final bake, film thickness, resin molecular weight, and varying solvent formulation has been examined.

Striking changes in physical and chemical properties have been found to occur in Epon films aged in oxygen at 180°C. Film density increases, some volatilization of resin takes place, oxygen enters the film and causes chemical alterations to the surface, and the permeability of such films toward helium and possibly toward water vapor falls off with time.

Infrared studies have given some insight into the mechanism of the oxidation reaction and these results have been correlated with the other physical film alterations into a theory of film failure which stresses the effect of dimensional changes on the loss of good protective coating properties.

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Deterioration of Synthetic Enamels

By S. Gusman and Aldenlee Spell, Rohm & Haas Co., Philadelphia, Pa.

The photodegradation of a benzoguanamine resin and a benzoguanamine resin-alkyd resin mixture on exposure to ultraviolet radiation was followed by direct infrared examination of thin films of these materials. Disappearance of triazine and phenyl rings and appearance of hydroxyl groups suggest photolysis and photo-oxidation as the photochemical mechanisms.

A mathematical treatment describes the photodegradation as a function of both depth into the film and time of ultraviolet irradiation. The data are discussed in terms of the two limiting cases: surface reaction and bulk reaction. An analysis is also made in terms of the general case and degradation profiles are calculated. The quantum yield was found to be approximately 4×10^{-4}, using some simplifying assumptions.

The implications of this investigation to deterioration of enamels outdoors are pointed out.

Liquid Epoxy Resins In Coatings

By W. A. Henson, R. F. Helmreich, D. D. Applegath, and S. R. Vranish, The Dow Chemical Co., Midland, Mich.

A liquid epoxy resin of low molecular weight, was formulated into coatings comparable to those based on solid epoxy resins. Seventy-three coatings, using 14 different curing agent and modifying resins, were evaluated. Solution properties, film physical properties, and chemical resistance were tabulated.

It was found that liquid epoxy resins of low molecular weight, can be formulated into excellent coatings. However, proper choice of curing agent composition and concentration is essential for optimum properties in a given end use. Handling characteristics of the liquid resin are good, and xylene is a satisfactory solvent for most liquid epoxy resin coatings. Proper solvent balance and solution aging time prior to film application are important in overcoming the tendency of polyamines to cause blushing during air drying. Pot life also is determined by solvent balance.

Excellent hardness is a characteristic of most liquid epoxy films, and in many cases is better than that of higher molecular weight epoxy films. Flexibility and impact resistance are good, except when the liquid resin is formulated with amino or phenolic resins. Adhesion is similar to that of solid epoxy resins, except when polyamines or phenolic resins are the curing agents.

Almost all the curing agents studied here can be used with the liquid epoxy resin to obtain excellent solvent and hot alkali resistance. Resistance to hot distilled water can also be obtained with the liquid resin and proper choice of curing agent, but in general, hot distilled water is an unexpectedly severe test. Hot acid resistance was shown to be good in several formulations of the liquid epoxy, particularly in epoxy-phenolic resin blends.

Film Curing by Esterification And Olefin Polymerization

By Sylvan O. Greenlee, John W. Pearce, and John Kawa, S. C. Johnson & Son, Inc., Racine, Wis.

Coating formulations based on mixtures of long-chain aliphatic acids and polyepoxides are converted by subjecting thin films to normal industrial baking varnish schedules. Conversion to influsible products is brought about by simultaneous esterification of epoxide groups and polymerization of olefin groups. The polyepoxides used include the epoxidation products of tetrahydrophthalic acid esters and of butadiene polymers. Unsaturated acids described as ingredients include wide variations in amount and type of unsaturation. Typical unsaturated acids used are oleic acid, soybean oil acids, China wood oil acids, sorbic acid, and dimerized vegetable oil acids. Where the polyepoxide is the epoxidation product of butadiene polymers, heat-curing products may be obtained by using saturated acids. The use of saturated acids is apparently possible, because the epoxidized butadiene polymers contain not only epoxide groups for esterification, but olefin groups for polymerization.

Such technique of formulating protective coatings has the advantage of eliminating the batch varnish cooking step, giving low viscosity products, and using polymerization-sensitive acids. Products possessing excellent water and alkali resistance may be so formulated.

Reaction of Polyamide Resins With Epoxy Resins

By Dwight E. Peerman, Wesley Tolberg, and Don E. Floyd, General Mills Research Laboratory.

Rates of reaction and degree of reaction for mixtures of polyamide and epoxy resins have been studied via infrared spectroscopy. Samples of the mixtures were prepared by forming thin films of the resins between potassium chloride plates. Spectra of the samples were recorded in the region of 10.95 microns to observe the disappearance of the oxirane oxygen band during curing of the compositions.

Samples containing a constant ratio of reactants were cured at room temperature and at 200°, 300°, and 400°F. A temperature of 300°F. was found to be optimum for most rapid curing and samples containing different ratios of reactants were cured at this temperature.

Rates of reaction were determined from rate of change of the intensity of the oxirane oxygen band and the final degree of cure was noted. The amount of unreacted oxirane oxygen was compared with flexural strength, hardness, compressive strength, and heat distortion temperature. Of these, heat distortion was most clearly associated with degree of cure, while other properties were less noticeably affected.

In addition, the curing rates and properties of amine-cured epoxy resins were determined and compared with those of the polyamide and epoxy resin blends. While in the latter, there was no detectable oxirane oxygen in the cured optimum blends, amine-cured epoxy resins invariably contained residual epoxy groups in spite of extended post cures at 300°F.

Temperatures at which optimum blends of polyamide and epoxy resins were cured also had a noticeable effect on the amount of residual oxirane oxygen content and consequently on the heat-distortion temperatures of the cast resins.

Calculation of Composition Of Epoxy Resin Esters

By L. G. Montague and K. A. Earhart, Jones-Dabney Co., Devoe & Raynolds Co., Inc., Louisville, Ky.

The discussion is divided into two parts: a brief review of the structures of the epoxy resins, and the theoretical considerations necessary for calculating the composition of epoxy resin esters, accounting for the water of esterification, and expressing the composition of the resulting products.

The chemistry of the bisphenol—epichlorohydrin reaction and the effect of varying the ratios of the reactants on molecular weight, epoxide equivalent, functionality, and equivalent weight, of the finished resin, are discussed.

In an epoxy resin-fatty acid ester reaction, water is evolved only from that portion of the fatty acids in excess of the amount needed to react with the epoxide groups. A simple equation to calculate water of reaction is given and suggestions are made on the methods of expressing formulas in parts and per cent of starting ingredients and per cent of ingredients in a completed ester.

In the interest of establishing a common language for expressing the composition of epoxy esters, several terminologies are suggested for consideration.

A graph is shown indicating theoretical and actual grams of water evolved during the formation of 100 grams of various esters. These esters were combinations of a selected epoxy resin and fatty acid varying from 100% resin to that ratio of the reactants necessary to form a theoretically complete ester.

Amines as Curing Agents Of Epoxy Resins

By A. Damusis, The Sherwin-Williams Co., Cleveland, Ohio.

Primary, secondary, and tertiary mono-, di-, and polyamines are compared in respect to their chemical structure, curing activities, and film properties. All the amines are divided into two separate groups—reacting bridging agents and cross-linking cata-

lysts; the first producing a semiflexible film, and the second a brittle film.

Proton-binding capacity of amines is correlated with their curing efficiency. The role of resonance effect of an aromatic group attached to the nitrogrn is observed. From this observation a conclusion is drawn. The resonance affects highly the curing efficiency of the amine catalysts and has no apparent influence on the amine bridging agents. Insulating groups between aromatic ring and amino nitrogen substantially eliminate resonance effect, and catalyzing efficiency of such compounds is high.

A series of amines is presented according to the increasing curing abilities of both types—bridging agents and catalysts.

Experimental data obtained on the testing of the paint films are correlated with the infrared examination graphs obtained on amine-catalyzed epoxy films after 15 minutes, 1 hour, 2 hours, 4 hours, 24 hours, and 30 days.

Epoxy Resin Esters Containing Tung Oil Fatty Acids

By Leo A. Goldblatt and Lucien L. Hopper, Jr., Southern Utilization Research Branch, Southern Regional Research Laboratory, U. S. Department of Agriculture, New Orleans, La.

Development of methods for incorporating tung oil fatty acids in epoxy resin esters is reported. The usual cooking procedures or schedules normally used for preparing epoxy resins of long-chain acids cannot be used with tung oil fatty acids because gelation occurs while the acid value is still high, and the products would generally not be gasproof. Epoxy resin-tung oil fatty acid esters of rather low acid value can be prepared by replacing part of the tung oil fatty acids with less reactive long-chain fatty acids and use of a two-stage cooking procedure.

Use of zinc resinate facilitates preparation of such esters of low acid value. Tung oil methyl esters may also be used with zinc resinate to produce epoxy resin esters of low acid value and good pigment-wetting properties. The products have properties similar to epoxy resin esters of other long-chain fatty acids but retain about two thirds of the triene conjugation present in the tung oil fatty acids used. Preliminary evaluation indicates that the epoxy resin esters incorporating tung oil fatty acids are useful for the same general purpose as the esters of other long-chain fatty acids. They dry very rapidly to give extremely hard finishes but lack the flexibility and are darker in color than similar formulations with dehydrated castor fatty acids. Replacement of some of the long-chain fatty acids with potentially fungcicidal acids, such as propionic acid, imparts some fungicidal activity.

Epoxy Resin—Phthalic Alkyds

By George R. Somerville and Donald S. Herr, Union Technical Service Laboratory, Shell Chemical Corp., Union, N. J.

It is generally recognized that oil-modified phthalic alkyd resins, while providing low-cost "nonyellowing" finishes, fall short of the physical and chemical resistance properties normally associated with the Epon resin esters. It has been felt desirable to combine the useful properties of both the Epon resin ester and phthalic alkyd coating materials, but because of the high functionality characteristics of the Epon resin and the phthalic anhydride, most previous attempts to effect the combination of the two materials resulted in gelation before low acid values could be obtained.

This paper presents a technique for reducing the functionality of Epon resin so that Epon resin-phthalic alkyds can be produced on a practical scale. The technique involves the formation of a partial ester on the Epon resin with the fatty acid desired through both the epoxide liniages and the hydroxyl groups of the resin, the resultant product having a hydroxyl functionality of between 1 and 4. Such an Epon resin partial ester is then introduced as a polyhydric alcohol in the formulation of phthalic alkyd resins, much as other polyhydric alcohols.

Epon resin-phthalic alkyds exhibit the combined desirable properties of both Epon resin esters and conventional phthalic alkyds and open the way to improved phthalic alkyds for surface coating formulations. This paper contains the formulation and test data on an Epon resin-phthalic lauric acid

alkyd useful for appliance top coats to demonstrate this improvement in alkyd properties.

Reaction Rates of Isocyanates with Amines

By R. L. Craven, Jackson Laboratory, E. I. du Pont de Nemours & Co., Wilmington, Del.

The reactions of aromatic isocyanates with amines in dioxane solution are complex processes exhibiting a greater rate dependence on amine concentration than on isocyanate concentration and also autocatalysis by product urea. A reaction mechanism consistent with the observed kinetics is formation of a complex between amine and isocyanate, followed by conversion of the complex to urea in steps involving either amine or urea. These reactions are also catalyzed by carboxylic acids and, to a lesser extent, by tertiary amines. Reaction rates increase with increasing base strengths of amine reactant. Alkyl substituents on the isocyanate decrease reaction rate.

Reaction of Aromatic Isocyanates With 1-Butanol

By J. J. Tazuma and H. K. Latourette, Central Research Laboratory and Westvaco Chlor-Alkali Division, Food Machinery & Chemical Corp., South Charleston, W. Va.

The kinetics of the reactions of aromatic isocyanates with 1-butanol have been studied by volumetric and dilatometric methods. The relative rates of reaction of 1,3-phenylene, 2,4-tolyene, 4-chloro-1,3-phenylene, 4,6-dichloro-1,3-phenylene, 2,4,6-trichloro-1,3-phenylene, 2,4,6-tribromo-1,3-phenylene, and tetrachloro-1,3-phenylene diisocyanates, and 2,4,6-tribromo-3-amino-phenyl and phenyl isocyanates were determined. The electronic and steric effects of the substituents on the rates of these reactions are discussed. The influence of hydrogen chloride and of boron fluoride (as the diethyl ether complex) on the rate of reaction of phenyl isocyanate with varying concentrations of 1-butanol has been investigated. This reaction exhibits general acid catalysis except when a large excess of 1-butanol is employed. A mechanism consistent with these observations is presented.

Effect of Catalysts, Inhibitors On Reaction of Isocyanates, Polyesters

By M. E. Bailey, C. E. McGinn, and R. G. Spaunbaugh, Allied Chemical & Dye Corp., Buffalo, N. Y.

Various catalysts and inhibitors were added to benzene solutions of tolylene diisocyanate and diethylene glycol adipate polyester. In each case the rate of the reaction which ensued was followed by observing the rate of disappearance of diisocyanate as measured by the absorption band at 4.5 microns in the infrared spectrum. The kinetics were first-order, since the diethylene glycol adipate polyester is used in large excess.

The following substances exerted catalytic effects, listed in order of increasing effectiveness: *N*-methylmorpholine, Dimethylethanolamine, *N,n*-diethylcyclohexylamine, triethylamine, and cobalt naphthenante. The following materials acted as inhibitors: hydrogen chloride, acetyl chloride, and chlorobenzoyl chloride.

Catalyst Studies In Urethane Reactions

By M. E. Bailey, A. Khawam, and G. C. Toone, Allied Chemical & Dye Corp., Buffalo, N. Y.

Reactions between an isocyanate group and another functional group containing labile hydrogen are activated to different degrees by various catalysts. In view of the industrial development that isocyanate-base polymers are undergoing, a convenient method for the measurement of catalytic activity would be not only of great interest, but also of considerable industrial importance. Such a method has been developed in our laboratory and is reported in another paper given in this symposium. The progress of the catalyzed reaction between tolylene diisocyanate and a diethylene glycol adipate polyester is followed by infrared measurement of the residual diisocyanate.

In this paper correlation of these reactivity curves with the practical use of the catalysts in the reactions involved in various urethane applications has been undertaken. These applications have included foams, films, coatings, and gelling rates of resin-isocyanate

mixtures. In general the agreement between the catalyst activity curves and the rate at which the catalysts activate reactions in actual applications is good.

Besides these catalysts for which infrared activity curves were available, another selected group was compared for activity in foams, films, and coatings. Again correlation was good between the different types of application.

Diisocyanate Derivatives

By W. J. Balon, E. Barthel, C. L. Kehr, E. O. Langerak, R. L. Pelley, D. M. Simons, K. C. Smeltz, and O. Stallmann, Jackson Laboratory, E. I. du Pont de Nemours & Co., Wilmington, Del.

Dimers, trimers, and ureas of certain aromatic diisocyanates have been prepared. Dimers are synthesized by treatment with alkyl or dialkylaryl phosphine catalysts. Ortho-substituted monoisocyanates and alkyl isocyanates do not dimerize. Diisocyanates bearing either a hindered or an alkyl isocyanate function are converted to the diisocyanato-substituted dimers.

Equilibrium conversion of toluene-2,4-diisocyanate to dimer is 74% in solvent with a phosphine catalyst. Dissociation of phenylisocyanate dimer and dimethyl toluene-2,4-dicarbamate dimer at 140°C. is first order. With phosphine catalysts the dimer is dissociated at much lower temperatures. Triethylamine catalyzes the alcohol-dimer reaction, forming allophanates, and increases the reaction rate by about 1000. This reaction is second order with respect to dimer and alcohol and the rate increases with increasing catalyst concentration. In acetic acid phenylisocyanate dimer reacts quantitatively with aniline to form 1,3,5-triphenyl biuret. The dimer ring resists oxidation, hydrogenation, hydrolysis, halogenation, and nitration.

Trimers can be synthesized by treatment with a catalyst consisting of sodium benzoate in dimethylformamide. Toluene-2,4-diisocyanate has been converted into the corresponding triisocyanato derivative by this catalyst. Ureas have been obtained by treatment of diisocyanates with water. Diisocyanato carbanilides derived from toluene-2,4- and toluene-2,6-diisocyanate have been synthesized in good yield and high purity.

Kinetics of Isocyanate Addition Reactions

By Maurice Morton and M. A. Deisz, Institute of Rubber Research, University of Akron, Akron, Ohio.

A kinetic study has been made of the reactions between isocyanates and the various functional groups involved in the formation of the urethane polymers. All the reactions appeared to obey second-order kinetics with regard to isocyanate disappearance, but the apparent rate constants were directly dependent on the initial ratio of isocyanate reactant, as previously found. Hence a comparison of reactivities could be made only under conditions of similar initial ratios of reactants.

The reaction of 1-butanol with two different diisocyanates—viz., toluene-2,4-diisocyanate (TDI) and methylene-bis (4-phenyl-isocyanate) (MDI)—was studied. As expected, the reactivities of the two isocyanate groups in TDI were found to differ by a factor of ten, while those of the MDI were similar in reactivity.

The reactivity toward phenyl isocyanate of the three "primary" compounds studied was in the following order: alcohol > water > carboxylic acid. The three "secondary" compounds showed the following order of reactivity toward phenyl isocyanate: urea > amide > urethane. In general, the primary compounds showed a considerably higher order of reactivity, as expected. Quantitative values of the rate constants and activation energies are presented.

Effect of Variables on Properties Of Polyurethane Coatings

By G. A. Hudson, H. L. Heiss, and J. H. Saunders, Mobay Chemical Co., New Martinsville, West Va.

The formulation of urethane coatings by the reaction of hydroxyl-bearing polyester resins with polyisocyanates has aroused much interest in the coatings field. Urethane coatings possessing desirable combinations of hardness, film toughness, and chemical resistance can be easily formulated to meet the requirements of a wide range of end uses.

The properties of a urethane coating

are a function of the type of polyester used, the type and amount of polyisocyanate used, and the means of curing the coating. This paper shows examples of how the basic properties of these coatings are affected by varying polyester, amount of isocyanate, and cure conditions. Data are reported on the effect of these variables on properties such as hardness, impact resistance, and chemical resistance.

Spray Method Of Applying Polyurethanes

By H. C. Fornwall, The DeVilbiss Co., Toledo, Ohio.

Field research and evaluation of the catalyst finishing problem dictated the requirements for the development of a satisfactory gun and auxiliary equipment. This involved the use of special metals plus a special hard coating, created for the exterior finish of the P-JGC gun. The liner of the catalyst host has been reformulated to handle the necessary corrosive materials. A complete line of pressure tanks for both catalyst and Iso-Foam, including aluminum insert containers, with or without agitators, is now available for production operations.

The key to a satisfactory use of catalyst spray type formulations centers on their viscosity. If the resins can be reduced in viscosity (below 60 seconds, No. 4 Ford cup or 250 centipoises at 80°F.) a satisfactory coating can be applied. This may be accomplished by reformulation, by the addition of necessary solvents, or by using a DeVilbiss paint heater. To date, the successful coatings incorporate catalysts having a viscosity range of 10 to 15 seconds, No. 4 Ford cup. The practical working ratio of catalyst to resin has been from 6 to 12% (by weight).

The present P-JGC catalyst gun will produce the required intermix (externally) of catalyst and resin. It also overcomes the vexatious obstacle of short pot life. Therefore, controlled films are now possible with the DeVilbiss spray method.

Solubilization-Depolymerization Of Urethane Foam Scrap

By J. Winkler, American Collo Corp., Ridgefield, N. J.

It is estimated that from 30 to 40% of the total production of urethane plastics, in particular of polyester-urethane foam, becomes scrap during manufacturing.

The present method was developed in 1953, in order to have on hand a method for regenerating scrap and waste. Urethane plastics are very high molecular materials belonging to the class of thermoset plastics, and, therefore, they do not melt without decomposition and are insoluble in known solvents. A method was worked out which consists of the following steps.

The shredded scrap is mixed with polyester, preferably the one from which the urethane plastic was made, in an amount sufficient to wet the shredded material thoroughly and to convert it to a semisolid pastelike mass. This material is now subjected in an autocalve at temperatures about 200°C. to small amounts of live, dry steam; the corresponding pressure is maintained during the process. The presence of a catalyst, preferably an organic hydroxyl acid, like citric acid, accelerates the process. This depolymerization-solubilization operation is considered finished as soon as the content of the autoclave is completely liquid, has a viscosity of not more than 20,000 cp. at 77°F., and is soluble in water-free ethyl acetate. Instead of a polyester, the solubilizing agent can later on be solubilized urethane itself. Subsequent decolorization of the solubilized material with commonly known solid absorbents like Florida clay, active carbon, etc., gives a product only slightly darker than a fresh polyester. The solubilized urethane plastic can react like a fresh polyester with isocyanates for the manufacture of foams, adhesives, coatings, and solid (bubble-free) urethanes.

(Conclusion of ACS abstracts)

Coating Finishes for Paper

By H. Beduneau: Revue des Produits Chimiques, vol. 58, No. 1,219, pp. 455-460 (1955).

There are today a great variety of coating products available for the treat-

ment of paper, each of which has its advantages and disadvantages. A few coatings serve for fairly general application; most of the coatings applied however are to give the paper special characteristics rendering it suitable for specialized employments. Thus for example, since one of the chief uses of paper is as a wrapping and packaging material, particularly for foodstuffs, one of the obvious objectives of a suitable paper coating for this purpose will be to render the paper impervious to moisture, to enhance its strength and tear resistance, to render it impervious to grease and fats. Other coatings serve to render the paper resistant to acids, alkalies and to chemical products for specialized wrapping purposes. Again, the coating applied to the paper can be for the purpose of giving greater rubbing and wear resistance; other coatings can serve the object of making the paper self-adhesive and so enhance its usefulness for wrapping and packaging applications.

For resistance to (water vapor) moisture, some products have a fairly high resistance although none are perfect; such for example, are chlorhydrate of rubber, polyvinyl chloride and certain of the cellulose base coatings. A great number of coating substances such as waxes, asphalts, vinyl resins, epoxy resins, urea-formaldehyde resins, rubber chlorhydrate and chlorinated rubber, phenol resins, and the polyamide resins, impart impermeability to water. Resistance to grease and fats is given by synthetic products such as sodium carboxymethylcellulose, methyl cellulose, polyvinyl alcohol, sodium polyacrylate, etc. Polyvinyl chloride and the copolymers of acetate and chloride of polyvinyl will serve to give simultaneous resistance to water and grease. Resistance to alkalies, such as soap products for example, is given by the vinyl, acrylic and phenol resins, chlorinated rubber, epoxy resins, ethyl cellulose, the styrenated alkyds, melamine resins, polystyrene and synthetic latex. Resistance to acids is given by the acrylic resins, the majority of the vinyl resins, the phenol resins and chlorinated rubber. Improvement of hardness and tear resistance is given by coating treatment with nitrocellulose, melamine resins, urea resins, chlorinated rubber and combinations of the polyamide and epoxy resins.

The products utilized for the coating treatment are mainly used in the form of solutions in an appropriate solvent. They can also be employed in the form of dispersions or aqueous emulsions and as organosols and plastisols in which the dispersion mediums are not water but organic solvents or plasticizers. With solvent solution, here it is of importance to operate with the inexpensive solvents and to work with solutions which while containing a high proportion of resin have a relatively low viscosity. Most often, solvent mixtures of alcohol and hydrocarbons are used and with these mixtures it is possible to prepare solutions containing up to 50 per cent of resin without the viscosity values attaining too high a figure. One of the disadvantages of the vinyl resins in this respect is that they require the more expensive solvents such as ketones or esters and it is difficult to prepare solutions containing more than 20 to 25 per cent of resin without the viscosity becoming excessively high. This holds good also for nitrocellulose. In such cases, solvent recovery installations will need to be installed.

The aqueous emulsion dispersions have the great advantage that the use of solvents is avoided and it is possible to prepare coating solutions with a high concentration which however, have a low viscosity. In a general manner, the use of aqueous emulsions is reserved for the treatment of surfaces of hydrophilic properties and the use of the coating varnishes for the treatment of surfaces of hydrophobic properties. The aqueous emulsions have the further advantage that fire risks from inflammable solvents are avoided.

The Newer Pigments and Lacquers

By A. Foulon; Farbe und Lack, vol. 61, No. 7, pp. 331-332, (1955).

The hydrated iron oxide pigments which are precipitated from iron salt solutions by basic agents, after dehydration give brown to black pigments which have only slight coloring power. With a recently developed process, pigments with a greater coloring power

and a better color tone can be produced, if water-soluble manganese compounds are added to the iron salts; this addition serves to change the color tone to a soft brown, black-brown and black, respectively. Raw materials are the waste acid liquors from steel pickling plants, which are best precipitated with a small excess of slaked and suspended milk of lime solution. The operation is conducted at 90°C. as better covering and softer pigments are obtained than with cold precipitation. Air oxidation is conducted up to a certain ratio of di- to trivalent iron (for example 1:3). Calcination at about 800°C. produces color-strong, bright brown pigments.

A new French process developed by F. Lehmann for the production of white lead by precipitation from lead acetate solution with carbon dioxide, employs a solution with controlled concentration, the lead acetate solution being presented in the form of a large surface to volume ratio by atomizing through nozzles, the lead acetate solution being very finely atomized in this manner; the solution is atomized into the reaction vessel and brought into intimate contact with carbon dioxide which is similarly atomized through injection nozzles. The white lead is precipitated in the finest particle form. This continuous reaction can also be further improved by the application of super-sonics to accelerate the settling of the pigment particles. The lead white can be simultaneously dried by blowing in preheated carbon dioxide gas and the addition of hot, inert reactions gases into the reaction vessel. The lead white is continuously removed from the bottom of the reaction vessel by conveyor worms.

With the manufacture of pigments by the wet process by double decomposition in aqueous solution, in addition to the insoluble pigments, solutions containing electrolytes are produced from which the pigments must be washed. With the process developed by Brintzinger, white and colored pigments can be produced by double decomposition without the formation of soluble by-products. For example, by the reaction of barium hydroxide barium oxide with compounds, form both an insoluble hydroxide or oxide as also an insoluble barium compound, such as barium sulfate, barium silicofluoride, barium chromate, barium fluoride or barium oxalate. With the reaction, the insoluble barium compound is absorbed or precipitated on to the oxide or hydroxide. The degree of dispersion of the precipitated pigment can be varied according to the temperature, concentration, protective colloid addition, etc. The pigments so obtained are further processed as usual.

As is known, pigments are produced by the reaction of colorless and colored salts in aqueous solution; to obtain various color tones, the precipitated pigment is ground dry with barium sulfate. Such pigments, however, have bad sedimenting properties in the paint because of their varying specific gravity. This disadvantage is avoided by mixing (Lehmann and Voss. Hamburg) a highly basic, hydrated salt, (for example, basic aluminium sulfate) or a highly basic silicate or hydrated metal oxides or hydroxides with a zinc tetramine solution, the solid substance filter-pressed and the solid residue hydrolized in water. Sedimentation in polar filming agents is considerably reduced as a result of the strong absorption between the two components and the suspension forces freed by the dipolar groups. Crystallisation of the zinc hydroxide is prevented by this absorption on the hydrated surfaces of the carrier substances and accordingly the zinc hydroxide can be reacted with other salts with colored anions (for example, potassium bichromate). By combination of the various components, pigments of any graduated color tone can be produced. Instead of the salts with colored anions, acid organic dyestuffs (for example, alizarin) can be partially or completely used. Such pigments are characterized by the fact that their particle size has colloidochemical dimensions and because of Brownian movement they are easily dispersable; they are also suitable as fillers for rubber or plastics.

The use of aluminium alcoholates in paints and finishes serves to reduce the drying time; the alcoholates function as catalyzers. The gel action which is obtained also allow of thicker paint coatings being applied; also after-tack is reduced and wrinkling tendencies suppressed. Paints and finishes which will store and stand, are obtained if

solutions of oils or resins in organic solvents are reacted with solutions of alkoxo salts in organic solvents. The stability of the solutions of the alkoxo salts is still further increased by the addition of tautomeric reacting bodies. Such bodies are ketonic acid esters or malonic acid esters, i.e. substances which are able to form enolic hydroxyl groups. The stability of the alkoxo salts depends not only on the nature of the central atom but also on the nature of the alkoxyl groups so that less-stable and strongly active solutions can be prepared as well as stable and less-active solutions. The multitude of the possible compositions of the alkoxo salts allow lacquers with specific characteristics to be obtained; thus for example, alcoxo salts with aluminium as the central atom, and a divalent metal as the outer atom, are particularly suitable for the production of good drying, resistant films. This holds good particularly for the cobalt-aluminium alcoholates as lacquer-processing agents.

Metal-Strengthened Linseed Oil Films

By F. Schlenker; Farbe und Lack, vol. 62, No. 1, pp. 9-14 (January 1956).

This process was first developed by Eigenberger who studied the strengthening of the oxidative drying film formers with aluminium alcoholates. In the presence of the aluminium alcoholates, the initial oxidation products of the oxidative drying film formers are absorbed, the degradation of the film-former is delayed and its aging properties are modified in an advantageous manner. By the incorporation of the aluminium metal in the film, which occurs as a result, the film formation and filming characteristics, for example the drying capability, the film hardness and the chemical stability and resistance are favorably influenced.

Auto-oxidized linseed oil films in the presence of aluminium butylate without the addition of driers in the air. The films become dust-dry within a few hours and harden-up in the course of one to two days to fully tack-free coatings. The amount of aluminium alcoholate is governed by the degree of oxidation of the linseed oil. Excess aluminium alcoholate in the film is a disturbing influence. If however, aluminium butyral is present in a stabilized form, then with continuing oxidation of the film, an aluminium polymerization gradually occurs, so that through this, even an excess of aluminium butylate, i.e. more aluminium than the Al—Z number shows, can be incorporated.

In a similar manner, other metal alcoholates can be used for the strengthening of linseed oil films. Thus, in an analagous manner, the effect of titanium and iron alcoholates was studied and interesting relationships are obtained when working with alkoxo salts. By co-ordinated action between central and outside atom of the alkoxo salt MeII [MeIII $(OR)_4]_2$ it is possible to produce systems with specific properties. Apart from alcoholates, other metal compounds can be used for the strengthening of the oxidative drying film-formers, these compounds having the characteristic that the metal is easily split-off and accordingly, are designated as "metal-active" compounds. As such are the compounds of di- or higher valent metals of enolic or ketolic hydroxyl groups, the hydroxyl group of the enol from being masked by chelate formation.

Interesting results have also been obtained in various oil-free synthetic resin systems with the incorporation of metal alcoholates or similar acting metal-organo compounds. Particularly striking are the results obtained with plasticized phenol resins and ethoxylene resins. These results with "metal active" compounds in drying oil and synthetic resin finish systems provide a and synthetic resin finish systems provide a new direction which offers a bridge between the filming agents of a purely organic nature and those with a dominating inorganic character and this would appear full of development promise in various directions.

Methods and Materials For Preventing Paint Skinning

By A. Clarke: Journ. Oil and Color Chemists Assoc., vol. 38, No. 4, pp. 191-199 (Great Britain, 1955).

To prevent or retard skin formation on paint finishes, the following possi-

bilities are available:

1. Exclusion of the action of oxygen.
2. Direct solution of the skin at the moment of formation.
3. Inhibitive influencing of the skin-formation procedure.

For practical reasons, the first method cannot be used with the production of paints. However, with the bulk storage of standoils or clear lacquer varnishes, a protective atmosphere of nitrogen or carbon dioxide can be used in the storage vessel. The second way can be at least partly used with finish production. To this method, there belong the known dipentene addition or the substitution of aliphatic by aromatic solvent mediums. Care should be taken however that through the solution of the (enriched with oxygen) skin, the characteristics of the paint finish are not adversely influenced.

The third possibility, on the other hand, is frequently employed. Its degree of efficiency depends on the fact that the amount and nature of the anti-oxidants added has a distrubing influence on the drying of the oil. Volatile anti-oxidants (for example, butyraldoxime) which evaporate with the solvent mediums during the course of the finish film drying, would therefore appear to be particularly suitable for application; with this it must be observed that in cases where the finish surface is continuously in contact with an air flow—as with dip tanks—this medium can fail.

A number of tests were described which were carried out with fatty, medium-fatty and styrolized alkyd resin finishes; further with finishes on a phenol resin lacquer and resin ester lacquer basis as well as with a very lean copal resin lacquer (Gold Size). For the anti-skinning addition, there were used butyraldoxime (B A O) and tertiary butyldimethylphenol (B D M P) in various amounts.

It was shown in a noteworthy manner that on standing in open ½ litre (one pint beakers), there were no clearcut differences in the skin formation on the finishes, even in those cases where the addition of the anti-skinning agent was large enough in amount to completely hinder the drying of the finish. The test results were better with the finish to standing in open, high glass tubes of one inch diameter. The skinning was observed in these vessels and after a certain period the drying characteristics were determined with the Beck-Koller drying tester.

As the most important result, it was established that even with the rapid drying styrolized alkyd resin finishes, which as a consequence of this, have a strong tendency towards skin formation, a skin formation can be prevented for 16 days by suitable additions without any lengthening of the drying time of the finish occurring. In general, the B A O addition gave better results with hard resin-containing finishes, while the cheaper B D M P addition was superior with alkyd resin finishes. Alkyd resin finishes and gold size require much smaller additions for effective skin prevention than the other finishes.

Chemistry of Complex Pigments Of Zinc or Cadmium and Chrome

By G. Cole and L. F. Le Brocq: Journ. Applied Chem., vol. 5, No. 4, pp. 149-172 (1955).

The authors were able to determine, by means of a study of the pH curves, the optimum conditions for the formation of chromates of the double, basic types, corresponding to the following general formula:

$R_2 CrO_4 . 3 MCrO_4 . M(OH)_2 . 2 H_2O$

in which R is Na, K or NH_4, and M is Zn or Cd.

The sodium-zinc, potassium-zinc, potassium-cadmium and ammonium-cadmium compounds were prepared. On the contrary, no sodium-cadmium compound was encountered and the ammonium-zinc compound was of a different type. The decomposition of these compounds by an alkali and by washing with hot and cold water (potassium-zinc and potassium-cadmium only) into basic compounds of zinc and cadmium was studied. The chromate of cadmium and the monoxychromate of zinc and cadmium were prepared. The identity of each compound was established by

the formation formula, the composition and X-ray diffraction as well as by the solubility. Several of the compounds obtained have a certain importance as paint pigments.

Zinc-Lead White Pigments In Corrosion-Protective Paints

By A. Foulon, Metalloberflaeche, vol. 10, No. 1, pp. 26-27 (January 1956).

As is known, high mechanical strength characteristics of the finish film are required for corrosion-protective organic finishes on metals. Of these mechanical characteristics of the paint film, the tensile strength and the elasticity (elongation properties) are dependent to a considerable extent on the molecular structure of the filming agent and also partly, on the pigments and fillers incorporated in the film. On the other hand, the tear strength and expansive properties of the film are practically dependent on the characteristics of the sub-surface. On every corroding metal surface there exist innumerable local cells with anodic and cathodic action, the mechanism of the metal corrosion being of an electro-galvanic nature.

The conception which was formerly held with corrosion-protective finishes, that one could suppress or at least reduce the corrosion by the application of coatings of suitable organic finishes to the metal surface, has now become somewhat obsolete. This conception was based on the reasoning that the metal base surface would then be protected from the aggressive influences of the air, moisture, and chemical-attacking agents. Today, it is known and realized that even the most dense and the thickest finish films still allow the above-mentioned corrosive agencies to penetrate through to the metal surface. If no corrosion of the metal occurs with a suitable applied rust-protective finish, then this has its basis in the fact that a high electrical resistance has been imposed between the individual anodic and cathodic corroding electrical circuits on the metal surface by the protective paint finish coating, so that these local cells can exert no harmful influence in the direction of promoting corrosion of the metal.

With pigmented anti-corrosion protective paint films, the nature and amount of the pigments present in the film is of significance in this connection. The ratio of pigment to filming medium in the finish is decisive for the degree of electrolytic resistance and accordingly, for the corrosion-protective action. Basic pigments such as, for example, the well known and much applied "Harzsiegel" zinc oxide, as do many other pigments, exert a corrosion-inhibiting action. This protective action can be ascribed particularly to the presence of small amounts of metal soaps in the finish system these being formed by reaction between the basic pigment and the oil-containing filming agent. The exact relationships in this respect are not yet precisely known, but it is known that a superfluity of metal soaps in the finish-complex system can be a distinct disadvantage, the effect being shown to be premature destruction of the protective finish film.

The character of the paint zinc oxide qualities mentioned above, which are obtained technically by the mutual volatilization of lead-zinc ores and accordingly possess a homogeneous distribution of the two components, from the chemical aspect is conditioned by the active pigment zinc oxide, as this as a base is capable of building with acids what are termed "soaps" (salts). From the paint finish point of view, this signifies that the zinc oxide forms partly soluble and partly insoluble salts (soaps) with the acids present in the fatty filming mediums present in the finish (for example linseed oil-standoil) which are brought into being during the drying of the finish film as free fatty acids; through this action there is obtained a considerably more rapid drying, through-hardening and better durability of the paint coating. As the filming agent for use with the zinc oxide, only those enter into consideration with an upper acid index number of five to six; this is in order to prevent viscosity increases or the formation of too-large an amount of zinc soaps.

Simulataneously however, the lead sulfate portion present in the zinc oxide, assists to an even greater extent in increasing the mechanical strength of the paint film and so improving the durability, weather resistance and corrosion-protective capacity, by the for-

mation of lead soaps. This natural composition of zinc oxide and basic lead sulfate is one of the chief advantages of the corrosion-resistant finish coatings prepared from the pigment and this will be clearly seen on consideration of the above-mentioned relationships which occur with finishes of this nature. For a lasting protective effect, even with a superior material such as the zinc-lead pigment mentioned, a three coating application should be given. With suitable priming of the metal surface, as for example with a red lead finish, a far-reaching, long term protection against aggressive corrosion mediums is obtained. The passivating or inhibiting effect given by the primer pigment supplements the protection afforded by the cover coats.

Light Stability Of Lead Chromate Pigments

By V. Watson and H. F. Clay, Journ. of Oil and Color Chem. Assoc., (Great Britain), vol. 38, No. 4, pp. 167-177, (1955).

The suggestion proffered previously by Lashof that the darkening of lead chromates could be use to a photochemical reduction is briefly examined. A new experimental work is described in which lead chromates of various types were irradiated by means of a mercury vapor lamp and the gaseous products were collected and analyzed. The results obtained, in general, are in accordance with the hypothesis of Lashof, but it seems probable that the oxygen produced is in the atomic and not molecular form.

The progress realized recently, from the viewpoint of stability, to light of these pigments, is surveyed. The crystallography of the lead chromates is considered and the hypothesis according to which the blackening of these pigments implies a change of the crystalline structure, is rejected.

Copper Phthalocyanine Pigments

Paintindia, vol. 4, No. 11, pp. 27-31, (1955).

Copper phthalocyanine occurs as the crystalline forms alpha and beta which can be utilizable or non-utilizable in the pigment industry. When copper phthalocyanine of the alpha form, which is utilizable, is ground dry with certain milling auxiliaries, soluble or insoluble in water, and in particular with sodium chloride, the characteristic coloration of the alpha form is preserved.

On dry grinding, with certain mill auxiliaries, the phthalocyanine of the beta form is transformed into the alpha form. The copper phthalocyanine of the alpha form, ground with mill auxiliaries, in the presence of certain organic solvents, is transformed into the beta form. When the beta form of the phthalocyanine, non-usable in the pigment industry, is ground with milling auxiliaries in the presence of certain organic solvents, it is transformed into a usable beta form.

Metallic Pigments

By G. W. Wendon: Jour. Soc. Dyers and Colorists, vol. 71, No. 3, pp. 125-130 (1955, Great Britain).

Paints based on the metallic pigments (Al, copper bronzes) are characterized by their agreeable appearance and their high reflective power as regards light and heat, from which is derived their employment for decorative purposes, exterior coatings of fuel and gasoline tanks, etc. The pigments should not be spherical but in the form of fine plates. They are prepared by impact grinding in ball mills in the presence of a milling fluid and of stearic acid, serving as lubricant and coating agent of the particles formed. The plate-like form and the judicious calibrating of these particles play a great role in the value of the pigments: density, covering power, coating power. These two last notions are explained and studied in detail.

The stearic acid used plays multiple roles; in certain cases, it is interesting to have pigments whose metallic sheen is other than that of silvery or gilt. The tinting of the metal in the pigment form is very delicate; the procedure based on the anodic oxidation of the aluminium is difficult to apply. Other tinting methods are based on the princi-

ple of mordanting. There can also be applied over the metallic paint film, a colored transparent varnish which gives a color-tone without supressing the metallic sheen.

Identification of the Epoxy Resins

By G. Lewin: Paint Manuf. (Great Britain), vol. 24, No. 12, p. 434.

It is not yet possible to separate quantitatively the epoxy resins from other types of resins, but certain reactions permit their identification pure or in their esterized forms, by separating them from the other resins by a vapor entrainment in the presence of hydrochloric acid. A solution of p-phenylenediamine, heated in the presence of epoxy resin, assumes a reddish tint which intensifies after standing at the ordinary temperature.

Efficiency of Chromate Pigments In Anti-Corrosion Primer Coatings

By H. G. Cole: Journ. Applied Chem., vol. 5, No. 5, pp. 197-208 (1955).

The tests were carried out on seventeen chromate pigments incorporated in a vehicle: mineral oil/coumarone, with applications on alloys of magnesium, aluminium and on semi-mild steel. These metals thus protected were subjected to the action of a sea-water spray. Based on the unit of weight of the paint, it was found that the best protection was obtained with strontium chromate. Good results were obtained with calcium chromate on sheets of Mg-Mn alloy; zinc tetraoxychromate gave good results with steel and on the aluminium alloys, and good results were obtained with a mixture of lithopone, talc, zinc chromate for the Mg-Mn alloy and on steel. The zinc monoxychromate and the chromates of zinc and potassium or sodium were found to give an average protection. Mediocre results were obtained with the chromates of cadmium, lead and of barium.

Distinction Between Rutile And Anatase Titanium Pigments

By R. I. Dantura: Verfkroniek, vol. 28, No. 2, pp. 39-40 (1955).

The application of the photographic method which has been previously described (*Verfkroniek, 1954, vol. 27, pp. 64-67*) to some pigments of titanium dioxide, shows that there exists a very clear ratio between the density of the negative and the crystalline type of the oxide, while the aptitude to chalking does not permit of indentifying in a precise manner these two forms. It is remarked in addition, that the reflecting powers of anatase and rutile for small wavelengths (360-450 m. microns) present important differences.

Titanium Pigments

Paint Manufacture (Great Britain), vol. 25, No. 1, p. 25 (1955).

In the last two years, the titaniferous pigments have consolidated their position of the principal pigments in the paint industry. There has not, however, been observed a development comparable to that which followed the introduction of fine particles of the rutile type, some five years ago. The author reviews recent laboratory work on the titanium pigments and discusses the results of recent experience.

Different Types Of Red Lead Pigments

By D. Kusman: Chimie des Peintures, vol. 18, No. 1, pp. 7-8, (1955).

The drying oil paints pigmented with red lead, when applied on steel, show the following properties: good adherence, film hardness, which increases with time, passivation of the steel surface. These interesting properties would appear to be due mainly to the formation of certain lead soaps. The initial hardening of the film is attributed to the presence of free PbO.

It has, however, been confirmed that the non-setting red lead pigment with 32.5% of PbO_2 (6% of free PbO) gives from the protective point of view, results as favorable as the former red lead pigment, which contained 15% of free PbO.

The dispersed red leads have interesting properties from the viewpoint of sedimentation, but some doubt has arisen regarding their effectiveness as regards the protection of metal surfaces. Tests conducted with a dispersed red lead pigment, manufactured by the oxy-calcination of a complex lead carbonate have, however, given favorable results.

Stoving Lacquers with Amines On Epoxy Resin Basis

By J. J. Zonsveld: Journ. Oil and Color Chem. Assoc., vol. 37, No. 414, pp. 670-675.

The author discusses the recent progress obtained by treating the epoxy resin lacquers with amines and by pre-condensation of the epoxy resin with bodies with transversal linkages, such as metaphenylene-diamine and certain phenolic resins.

After the pre-condensation, there exist enough epoxy groups in the filming agent to permit its treatment by the addition of amines. A better fluidity of the paints, the absence of haze and bloom in the film, and an increased resistance to moisture, are some of the advantages obtained by this technique.

Heptanoic Acid in Alkyd Resins

By H. W. Chatfield: Paint, Oil and Color Journ., (Great Britain), vol. 127, No. 2935, pp. 153-155, (1955).

The partial substitution of phthalic anhydride by heptanoic acid, facilitates the preparation of the pentaerythrite alkyd resins and improves their compatibility with the amine resins. The films obtained are very brilliant and have excellent adherence and good tenacity. The presence of heptanoic acid in the alkyd resins modified with dehydrated castor oils permits retarding the gelification of these resins and correspondingly improves the properties of the stoving lacquers.

Rutile Titanium Dioxides

By J. Taylor: Journ. Oil and Chem. Assoc., vol. 38, No. 5, pp. 233-249 (1955).

The titanium dioxide pigments of the rutile type suffer from certain defects inherent to their process of manufacture: presence of aggregates; difficulty of dispersion; too high a content of salts soluble in water. The various subsequent treatments applied to improve these pigments consist principally in an aqueous dispersion of the pigment by means of special agents. The non-dispersed aggregates are eliminated and the finest fraction of the pigment is flocculated, filtered and dried.

The comparison of pigments thus treated and non- or partially treated permitted establishment of a clearcut improvement regarding the facility and stability of dispersion, durability to exterior influences (resistance to chalking) and in the composition for primer coatings on metals subjected to the action of detergents.

Chemistry of the Styrenated Oils

By J. B. Crofts: Journ. Applied Chem., vol. 5, No. 2, pp. 88-100, (1955).

The action of styrene on the methylic esters of a certain number of acids of drying oils and of dehydrated castor oil was studied. The research was conducted at 140°C. in the absence of oxygen, and without the addition of catalysts. The products obtained were of 4 types and their nature was precised by chemical analyses and spectroscopic analysis and by the determination of the molecular weight.

Emulsions of Polymerized Materials

By J. O. Cutter: Paint Manuf. (Great Britain), vol. 24, No. 10, pp. 337-340.

The theory of polymerization can be applied to the particular case of emulsions. It is important to be able to control the chemical stability, the viscosity and the mechanical stability of the emulsions of polymerized materials. Some methods for the measurement of these characteristics are indicated.

NEWS

Special Courses Offered By Newark Engineering

Two laboratory courses in Coatings Technology and a conference on the Chemistry and Physics of Pigments are being offered by the Newark College of Engineering, 367 High St., Newark 2, N. J.

The courses have been organized in cooperation with the New York Paint, Varnish, and Lacquer Association and the New York Paint and Varnish Production Club by the Special Courses division of the college.

One laboratory course, Basic Coatings Laboratory Procedures, will consist of twelve weekly sessions to be held in the college's Mullaly Memorial Paint Laboratory, Wednesday evenings, beginning Sept. 26.

The second, Advanced Lacquer Technology, has been planned for experienced formulators, chemists, and technically trained research, production, application, administrative and sales personnel, and will also consist of twelve weekly sessions, beginning Tuesday evening, Oct. 2.

The conference, beginning Monday, Oct. 8, is one of three series on coatings to be offered this fall by the College's Special Courses Division. All are under the general supervision of Frederick W. Bauder, Professor in Chemistry at NCE, and a recognized authority on paint technology. The other two are Advanced Lacquer Technology and Basic Coatings Laboratory Procedures.

The conference on pigments has been planned, according to Professor Bauder, for formulators, chemists, physicists, research men, and technically trained production application, administrative and sales personnel in the coatings and printing ink industries.

The lectures will include dispersion, flocculation and surface tension relations; polarity, absorption, radiant energy; optical and physical considerations of the pigment-vehicle system, and the chemistry and application properties of organic, inorganic and metallic pigments.

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Moves to Attleboro, Mass.

Instrument Development Laboratories, Inc., research and development specialists in the field of precision scientific instruments and electronics, and manufacturers of Color-Eye, the electronic color comparator, has moved its main office and factory to Attleboro, Mass.

According to Phillip M. Engel, vice president and general manager, the complete administrative, sales, research and development, and manufacturing activities have been transferred from Needham Heights, Mass., to the new location.

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UBS Chemical Expands

A $400,000 extension of the UBS Chemical Corporation's Cambridge, Mass., polymer emulsion plant which greatly multiplies the firm's output capacity of Ubatol, Unibac and Hycryl polymers has just gone on-stream.

Engineered by the Badger Manufacturing Co., also of Cambridge, the polymer emulsion plant is completely independent of all other UBS manufacturing activities. Ubatol, Unibac and Hycryl series polymers are used in paint, paper, textile, leather and other industries.

NEWS

Hercules Cellulose Dept. Opens New St. Louis Office

The opening of a new sales office in St. Louis for the cellulose products department of Hercules Powder Co. was announced last month. It will be located in the Continental Building, 3615 Olive St., where sales offices of two other Hercules departments, synthetics and naval stores, also are maintained.

R. R. Stover

The new cellulose products department office, a suboffice under direction of the department's Chicago district, will be under the direction of Robert R. Stover, technical sales representative. Mr. Stover has been with Hercules since 1950, and has had considerable experience as technical sales representative for the department's products in both protective coatings and plastics. He has worked in both the Wilmington and New York sales districts as a technical sales representative.

The territory which will be serviced by the new office includes southern Illinois, Missouri, Kansas, Oklahoma, and Texas. All of the department's principal products, including nitrocellulose, cellulose acetate, chlorinated rubber (Parlong), chlorinated paraffin (Clorafin), ethyl cellulose, cellulosic molding powders (Hercocels), and low pressure polyethylene (Hi-fax) will be handled by the new office.

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Carbon Black Film Available

Modern production and industrial uses of carbon black are described in a 31-minute, 16 mm., sound and color film. Entitled, "Readin'—'Ritin'—'Ridin' with Carbon," the film will be loaned gratis by Columbian Carbon Co., 380 Madison Ave., New York 17, N. Y. Inquiries should be addressed to the company's public relations department.

Spencer Kellogg Expands

Spencer Kellogg and Sons, Inc., Buffalo, N. Y., has announced purchase of properties outside Breckenridge, Minn., for the construction of a processing plant.

The company has also announced the conclusion of an agreement with Honeymead Products Co. to share its newly expanded processing and refining facilities at Mankato, Minn. This is expected to give Spencer Kellogg immediate national distribution of its soybean products.

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Westwood Moves Office

Westwood Chemical Co., New York area sales representative for Synthetic Products Co. and Archer-Daniels-Midland Co., both of Cleveland, has moved to larger quarters at 342 Madison Ave., New York 17, N. Y. The telephone number, OXford 7-2674, remains unchanged.

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J & L Steel Appoints Agent

Jones & Laughlin Steel Corp., container division, has announced the appointment of Industrial Steel Container Co., St. Paul, as its exclusive distributor in the St. Paul-Minneapolis area.

The St. Paul company will represent the full-line of containers manufactured by the container division of Jones & Laughlin, including steel drums and pails of every size and guage and designed to fit every type of need with special lithography identification, according to G. K. Hubbard, general manager of the J & L container division.

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Stresen-Reuter Appoints

Fred'k A. Stresen-Reuter, Inc., has announced that the West Coast sale of its raw materials to the paint and printing ink industries will be handled exclusively by the E. S. Browning Co., 2321 Yates Ave., Los Angeles and 1515 Third Street, San Francisco.

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U. S. Radium Moves to N. J.

The United States Radium Corp., producer of sealed radiation sources and radio-isotope-activated light sources, has moved its general offices from Manhattan to its new suburban office building in Morristown, N. J.

N. Dakota Get- Together

The annual get-together of the graduates of North Dakota Agricultural Paint School will be held in the Julep Room of the Netherland-Hilton Hotel on Tuesday, October 23rd from noon to 1:30 P.M. during the annual Federation Meeting.

Dr. Wouter Bosch will report on school activities.

P.V.O. Names N. Y. Distributor

Pacific Vegetable Oil Corp. has appointed Welch, Holmes and Clark Co. of 1 Hudson St., New York City, as distributors of P.V.O. products in the metropolitan New York area and certain parts of New York State, New Jersey and Pennsylvania.

Short Paint Course At U. of Fla. Jan. 28-Feb. 1, '57

The program and registration requirements of the Short Course in Paint Technology at the University of Florida, Jan. 28-Feb. 1, 1957, have been announced by Henry F. Payne, Professor in Charge of Organic Coating Research and Technology. The Course is sponsored by the College of Engineering and the Chemistry Department in cooperation with the Southern Paint and Varnish Production Club.

The speakers will review the fundamental aspects and raw materials for coatings, the equipment for manufacture of paints, and the architectural and industrial applications for coatings. The speakers include: Malcolm M. Renfrew, Director of Research and Development, Spencer Kellogg and Sons; Fred K. Quigley, Jr., Coatings Technical Service, Dow Chemical Company; John D. Beggs, Sales Manager—Resin Division, National Starch Products, Inc.; Gerould Allyn, Resinous Products Division, Rohm & Haas Company; W. G. Vannoy, White Pigments—Sales Service Laboratory, E. I. DuPont de Nemours & Co.; A. C. Elm, Research Department, The New Jersey Zinc Company; R. F. Wint, Coordinator—Coatings Laboratory and G. N. Bruxelles, Hercules Powder Company; R. J. Wirshing, Research Staff, General Motors Corporation.

Because the speakers time necessarily is limited at Short Courses, a preprint booklet will be prepared containing the complete papers of all speakers. The booklet will be sent to those who register to enable them to study the papers and be better prepared for discussion. Additional time for discussion will be provided at the two after-dinner open forums.

The registration fee is $20.00. This will include the preprint booklet and the two dinners but not lunches or room accomodations.

For complete details write Professor Henry F. Payne, University of Florida, 401 Engineering and Industries Building, Gainesville, Florida. Please make checks payable to the University of Florida.

TECHNICAL Bulletins

VISCOMETERS

A new eight-page catalog for the Brookfield Synchro-lectric Viscometer line gives complete information on the various models and accessories available, as well as a wealth of interesting information on the general subject of viscosity. Available from Brookfield Engineering Laboratories, Inc., Dept. PVP, 240 Cushing St., Stoughton 9, Mass.

ISOCYANATES

Two isocyanates—"Papi-1," or polyaryl polyisocyanate, and "Bunco," or n-Butylisocyanate—are described in technical data sheets released by The Carwin Co., Dept. PVP, North Haven, Conn. The sheets list physical properties, potential applications, availability, and bibliography. The sheet on "Papi-1" contains, additionally, a discussion of coatings, adhesives, foams and resins.

CARBON BLACK

A technical data sheet on carbon black for industrial use has been published by Columbian Carbon Co., Dept. PVP, 380 Madison Ave., New York 17, N. Y. The sheet discusses base and aqueous dispersions, as well as Mapico colors and bone blacks.

HOMOGENIZER-MIXER

A high-speed, high-shear homogenizer-mixer called the Eppenbach Homo-Mixer is described and illustrated in a new eight-page catalog, No. 402-R-2 offered by Gifford-Wood Co., Dept. PVP, Graybar Bldg., Hudson, N. Y.

The Eppenbach Homo-Mixer is applicable to a wide range of chemical processing operations, including the blending and homogenizing of paints, pharmaceuticals, cosmetics, heavy chemicals, plastics, inks and paper products. The catalog describes the blending action of the Homo-Mixer's rotor-stator mechanism, which subjects materials to intense forces of impact and hydraulic shear.

Other advantages discussed and illustrated include: minimizing of excessive air; simplicity of operation; easy maintenance; and adaptability of the unit to different operations, such as batch-type or continuous flow type.

SMOKE CONTROLLER

Data Sheet 10.14-2a describes the revised Brooke Smoke Density System using Brown ElectroniK Recorders. Good combustion efficiency and compliance with anti-smoke laws are claimed assured by this equipment, whose many features are said to guarantee clean lenses and long, dependable service life. Available from Minneapolis-Honeywell Regulator Co., Dept. PVP, Industrial Div., Wayne and Windrim Aves., Philadelphia 44, Pa.

CALENDAR OF EVENTS

Oct. 22-24. 34th Annual Meeting of Federation of Paint and Varnish Production Clubs and 21st Paint Industries' Show, Netherland-Plaza Hotel, Cincinnati, Ohio.

Nov. 1-3. National Paint Salesmen's Assoc., Hamilton Hotel, Chicago.

Nov. 7-9. Retail Paint & Wallpaper Distributors of America Convention, Hotel Sherman, Chicago.

Nov. 12-14. 68th Convention of National Paint, Varnish and Lacquer Assoc., Statler Hotel, Los Angeles, Calif.

Production Club Meetings

Baltimore, 2nd Friday, Park Plaza Hotel.

Chicago, 1st Monday, Furniture Mart.

C.D.I.C., 2nd Monday.
- Cincinnati — Oct., Dec., Mar., May, Hotel Alms.
- Dayton — Nov., Feb., April, Suttmilers.
- Indianapolis — Sept., Claypoll Hotel.
- Columbus — Jan., June, Fort Haynes Hotel.

Cleveland, 3rd Friday, Harvey Restaurant.

Dallas, 1st Thursday after 2nd Monday, Melrose Hotel.

Detroit, 4th Tuesday, Rachham Building.

Golden Gate, 3rd Monday, E. Jardin Restaurant, San Francisco.

Houston, 2nd Tuesday, Bill Williams Restaurant.

Kansas City, 2nd Thursday, Pickwick Hotel.

Los Angeles, 2nd Wednesday, Scully's Cafe.

Louisville, 3rd Wednesday, Seelbach Hotel.

New England, 3rd Thursday, University Club, Boston.

New York, 1st Thursday, Brass Rail, 100 Park Ave.

Northwestern, 1st Friday, St. Paul Town and Country Club.

Pacific Northwest, Annual Meetings Only.

Philadelphia, 3rd Wednesday, Philadelphia Rifle Club.

Pittsburgh, 1st Monday, Gateway Plaza, Bldg. 2.

Rocky Mountain, 2nd Wednesday.

St. Louis, 3rd Tuesday, Kings-Way Hotel.

Southern, Annual Meetings Only.

Toronto, 3rd Monday, Oak Room, Union Station.

Western New York, 1st Monday 40-8 Club, Buffalo.

RIBBON TYPE MIXERS

Eight different sizes of ribbon type mixers, available with choice of six different agitator types, are described in Bulletin #300 released by The Cincinnati Hildebrand Co., Inc., Dept. PVP, 3410 E. Beekman St., Cincinnati, Ohio.

Suitable for processing crystalline and sharp powders, dry colors, and for cutting fats, oils and shortening into dry powders and flours, the mixers may be provided with any of six various agitators, depending on the type of product to be mixed.

Agitators described include center discharge cut-out type, continuous ribbon, "dry-color," T-head reducing, center discharge continuous, and "cut-it-in" type. Each agitator is designed for use in mixing specific types of products.

ORGANIC PRODUCTS

A new 12-page catalog of "Sharples" brand synthetic organic chemicals lists 77 commercially available products with formulas, product descriptions and suggested uses. Included in the extensive line are alcohols, esters, chlorine compounds, amines, ureas, dithiocarbamic acid derivatives, alkyl phenols, organic sulfur compounds, hydrocarbons, surface active agents and fuel gas odorants.

In addition the brochure contains detailed information on 22 semi-commercial and 17 experimental compounds, samples of which are available in limited quantities from laboratory and pilot plant production. Copies of the publication are available from Pennsalt Chemicals, Dept. PVP, 3 Penn Center Plaza, Philadelphia 2, Pa.

CHEMICALS

A new four-page technical bulletin, No. 908-A, showing specifications and typical uses of Hydrofol fatty acids, glycerides, sperm oils and fatty alcohols has been released by the Chemical Products Div., Archer-Daniels-Midland Co., Dept. PVP, 2191 W. 110 St., Cleveland 2, Ohio.

Featured is a chart on new saturated and unsaturated higher fatty alcohols currently being produced in volume from the company's new multi-million dollar plant in Ashtabula, Ohio.

PAINTING BULLETIN

The Steel Structures Painting Bulletin, an 8 page technical publication issued quarterly, and devoted to the protection of structural steel through the use of paints and coatings, reports results of paint testing, abstracts of pertinent technical articles, investigations of paint failures, and reports of highly successful paint performances. Edited by Dr. Bigos, director of research for the Council, the bulletin is available from the Steel Structures Painting Council, Dept. PVP, 4400 Fifth Ave., Pittsburgh 13, Pa.

MOLYBDENUM CHEMICALS

A four-page bulletin, Cbd-9, "Organic Complexes of Molybdenum," summarizing all available information on the formation, formula, chemical properties, and uses of organic complexes and organometallic compounds of molybdenum has been published by Climax Molybdenum Co., Dept. PVP, 500 Fifth Ave., New York 36, N. Y. The bulletin also lists 32 references to sources of more complete information.

RESINS

Neville Products To Make Your Products Better" is the title of a new eight-page leaflet issued by the Neville Chemical Co., Dept. PVP, 1938 Neville Island, Pittsburgh 25, Pa., covering the company's full line of chemicals and containing, in addition to product specifications, data on the solubilities and compatabilities of Neville's resins. Featured also are charts giving application suggestions.

PROTECTIVE COATING INK

Air Force-sponsored studies of heat resistant corrosion protective coatings for low allow steels for use in aircraft are described in a report available from the Office of Technical Services, U. S. Department of Commerce, Washington 25.

The report, *Evaluation of Surface Treatments for Low-Alloy Steels*, was prepared by Sam Tour of Sam Tour & Co., Inc. for Wright Air Development Center, and published in two volumes: Part 1—PB 121087, Nov. 1954, 29 pages, 75 cents; Part 2—PB 121088, Nov. 1954, 21 pages, 75 cents.

The first part presents a method for testing protective coatings for low alloy steels in two artificially created environments. Part two describes diffusion coatings produced by chromizing and siliconizing which showed considerable promise as protective coatings for low to medium carbon, plain carbon or low-alloy steels at temperatures up to 1200°F.

HEAT TRANSFER COSTS

Informative data on how to cut heat-transfer costs in a wide range of industrial applications is contained in a new catalog published by Tranter Manufacturing, Inc., Platecoil Division, Dept. PVP, Lansing 4, Mich.

Bulletin IP-356 features a detailed description of how Platecoil units are constructed, emphasizing how they have been engineered to overcome all types of heat-transfer processing difficulties. The bulletin lists and illustrates ten major advantages claimed for the Platecoil, and shows how each of them contributes to savings in installation, upkeep, and in initial cost. Complete specifications and dimensions are listed for all four major styles in which the Platecoil is available. Also included is a table for converting lineal feet of pipe coil into equivalent square feet of Platecoil.

CLARIFYING FILTERS

Brosites Products Corp., Dept. PVP, 50 Church St., New York 7, N. Y., has issued a four-page, illustrated bulletin giving the latest information on its vertical plate and frame liquid clarifying filters. These units are designed for filtering varnishes, alkyd resins, fish oils, solvents and other liquids.

This bulletin, #20, lists advantages of vertical plate design, gives operating procedures, has engineering data, a specification table, and illustrative diagrams.

ANNOUNCEMENT

THE 1956 REVIEW OF THE PAINT INDUSTRY IS OPEN FOR ADVERTISING SPACE RESERVATIONS.

PUBLICATION DATE IS FEBRUARY, 1957.

FOR CLOSING DATES, RATES AND OTHER DETAILS, WIRE OR WRITE ADVERTISING DEPT., PAINT AND VARNISH PRODUCTION, 855 AVE. OF THE AMERICAS, NEW YORK 1, N. Y.

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LIFT TRUCKS

Latest trends in lift truck design are shown in a new 12-page brochure of industrial lift trucks manufactured by Hyster Co., Dept. PVP, 2902 N.E. Clackamas St., Portland 8, Ore.

Well illustrated and printed in two colors, the booklet is designed for quick reference of twenty-five different industrial truck models ranging in capacity from 1000 to 30,000 lbs.

Spotlighted are the all-new 3000, 4000 and 5000 lb. capacity series on pneumatic tires, the Hyster "Space Saver" series of the same capacity on cushion tires and the exclusive "Monomast" lift trucks. An advanced-design yard crane, Model KE "Karry Krane" of 10,000 lbs. capacity, is also described. The booklet also illustrates several popular lift truck attachments, including the Hyster-developed "Load-Grab."

DICHLOROPHENE

Technical Bulletin D-2, a complete revised comprehensive bibliography of the literature on G-4 (Dichlorophene) has been published by Sindar Corp. Dept. PVP, 330 W. 42 St., New York 36, N. Y. The bibliography contains abstracts of some 109 scientific trade articles, as well as abstracts of 12 patents both foreign, and domestic.

The bulletin has been indexed so that any abstract on a given subject can be easily located. The index is divided into seven major categories including: Biological Properties, Compatibility, Patents, Physical and Chemical Properties, Test Methods, Toxicological Properties and Uses. These categories are further subdivided to give the reader easy access to any particular subject of interest.

COATING RESINS

A 48-page revised technical data manual on Coating Resins contains sections on Rezyl Resins, Cycopol Resins, Beetle Resins, Cymel Resins, and Phthalic Anhydride. Copies may be obtained by writing to Plastics & Resins Div., American Cyanamid Co., Dept. PVP, 30 Rockefeller Plaza, New York 20, N. Y.

VINYL ACETATE

A new 20-page bulletin on vinyl acetate monomer has been published by Air Reduction Chemical Co., Dept. PVP, 150 E. 42 St., New York 17, N. Y. In addition to essential information on physical properties, grades, specifications and handling, the bulletin also includes details on polymerization and chemical reactions of vinyl acetate monomer. All data is fully referenced.

METHYL LINOLEATES

Chemical analysis, characteristics, comparisons and evaluations are contained in a 6-page brochure on the company's new, highly versatile methyl linoleates now being offered to alkyd and polymer manufacturers. Basis for these new products is safflower oil. Write for Bulletin No. ML-1 to Pacific Vegetable Corp., Dept. PVP, 62 Townsend St., San Francisco, Cal.

PAINTING FAILURES

In a leaflet entitled "Painting" made up by the Coatings Section of Foster D. Snell, Inc., Dept. PVP, 29 W. 15 St., New York 11, N. Y., the problem of painting and coating failures and what can be done to salvage certain situations are briefly discussed. Typical cases are cited pointing out the actual problem and how the Snell laboratories were effective in aiding or saving the situation. Advice and suggestions are given to those in the coatings industries as to how costly mistakes can be avoided.

GLASS BOTTLE VALVE

The Valve Division of the Risdon Manufacturing Co., Dept. PVP, Naugatuck, Conn., announces the publication of a bulletin on the Risdon glass bottle valve. A comprehensive presentation, the new publication offers basic information on pressurized packaging, and outlines, in text and diagrammatic form, the various applications of the valve, with Standard, "Micro-Mist" and Foam actuators.

ASTM 1955 PROCEEDINGS

The 1955 edition of the ASTM "Proceedings" has recently been published. The 1264-page volume records the technical accomplishments of the American Society for Testing Materials for the year 1955. It includes many technical reports and papers together with discussion which has been offered to the Society during the year and accepted for publication in the Proceedings.

In addition to the papers and reports embodied in the Proceedings, there are listed in the table of contents all symposiums published separately as Special Technical Publications (STP's) and all papers published in the ASTM Bulletin.

Copies may be purchased from American Society for Testing Materials, Dept. PVP, 1916 Race St., Philadelphia 3, Pa. Price is $12.00 per copy.

MONOMERS

A new folder, F-40033, gives important physical properties and suggested uses for the 36 monomers that are available from Carbide and Carbon Chemicals Co., Dept. PVP, 30 E. 42 St., New York 17, N. Y.

Polymers and copolymers prepared from these monomeric compounds are used in the manufacture of adhesives, plasticizers, textile and leather finishes, synthetic fibers, surface-coating materials, and other resinous compounds that have many important applications. In addition to their extensive use in polymer applications, these compounds are reactive intermediates for the synthesis of many useful materials such as pharmaceuticals, insecticides, oil additives, dyestuffs, perfumes, and plasticizers.

TESTING LABORATORY

To enable executives, engineers and others in industry and government to evaluate its capabilities, a new 72-page bulletin covering its services and facilities has just been published by the Electrical Testing Laboratories, Inc., Dept. PVP, 2 E. End Ave., New York 21, N. Y.

The bulletin contains more than 70 photographs and covers typical measurements and determinations made on hundreds of products and materials. In addition, it catalogues laboratory equipment available for limitless assignments in the fields of testing, applied research, and engineering analysis. This information is subdivided into the areas of chemical, electrical, electronic, mechanical and physical, and photometric, radiometric, and colorimetric testing. Similar information is given on spectroscopy, photomicrography, environmental, near infrared and ultraviolet testing.

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